

CALIFORNIA INSTITUTE OF TECHNOLOGY
EARTHQUAKE ENGINEERING RESEARCH LABORATORY

ANALYSES
OF
STRONG MOTION EARTHQUAKE ACCELEROGRAMS

Volume IV - Fourier Amplitude Spectra
Part B - Accelerograms IIB021 through IIB040

EERL 73-100

A Report on Research Conducted Under a Grant
from the National Science Foundation

Pasadena, California

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ABSTRACT

This is the second report (Part B) of a series (Volume IV series) presenting Fourier amplitude spectra for earthquake ground motions and for structural response accelerations. Volume IV, Part A, Report No. EERL 72-100 included an introduction summarizing Fourier spectrum techniques in earthquake engineering as a background to the use of the data. For each earthquake accelerogram, two spectrum plots are given - a Fourier amplitude spectrum versus frequency on a linear scale, and a log-spectrum, log-frequency plot. In the series, Fourier amplitude spectra will be given for all corrected accelerograms, including building response measurements. The records analyzed in Volume IV, Part B were the corrected data of Volume II, Part B, Report No. EERL 72-50 and appeared in their uncorrected form in Volume I, Part B, Report No. EERL 70-21.

TABLE OF CONTENTS

	<u>Page</u>
Abstract	
Preface	1
Index of Earthquake Records, Earthquake Data and References	5
Plots of Fourier Amplitude Spectra	12
List of EERL Reports Available from NTIS	130

PREFACE

This report, Volume IV, Part B, Report No. EERL 73-100 is the second report of the Volume IV series presenting Fourier spectrum curves calculated from corrected strong-motion accelerograms including measurements in structures as well as at ground sites. An extensive introduction was prepared for Volume IV, Part A, Report EERL 72-100, where details of the methods used can be found together with examples of applications to various problems of earthquake engineering and strong-motion seismology. That introduction should also serve as a basic summary of background information for users of the data.

The series of reports in Volume I present "uncorrected" digitized and plotted strong-motion earthquake accelerograph data, while the series in Volume II present corrected digitized data prepared so that the maximum information over the widest practicable frequency range would be available. The corrections include high frequency smoothing, an instrument correction to account for the high frequency response characteristics of the accelerograph transducer, and long period filtering to ensure a uniform type of base-line adjustment.

The records included for Fourier spectrum analysis in this report, Volume IV, Part B, were presented in "uncorrected" form in Volume I, Part B, Report No. EERL 70-21 and in corrected form in Volume II, Part B, Report No. EERL 72-50. The response spectrum analysis for these records appeared in Volume III, Part B, Report No. EERL 73-80.

A thorough description of the naming of component directions of the records was given in Volume II, Part B, Report EERL 72-50. Consistent

with this, the component direction, where it appears in this report, refers to the direction of the transducer pendulum motion for trace "up" on the record when viewed in the normal way with time increasing from left to right. Some reproductions in the publication "United States Earthquakes" issued by the National Oceanic and Atmospheric Administration (formerly the Coast and Geodetic Survey) have reversed component directions apparently to indicate true ground motion. This ambiguity led to a few cases of incorrect component description in Volume IV, Part A and a complete list of these in their correct form is included in this report. However it must be kept in mind that the spectra calculations of Volume IV are concerned with the amplitude spectrum and the particular component sense is immaterial.

For each component in the following pages the Fourier amplitude spectrum is presented in two forms - a linear plot and a log-log plot. Details concerning identification are given at the top on each plot. The second line gives the name, date and time of occurrence of the earthquake; the third line is comprised of two labels, the observation station and the component processed. The Roman numeral "IV" in the first identification label indicates that the results pertain to the fourth stage of data processing, i. e., Volume IV of Fourier spectra of accelerogram records already corrected for baseline adjustment and instrument response. The letter "B" following the Roman numerals implies that the processed record belongs to Part B of Volume IV. The three digit number completing the first label is the Caltech Reference Number for the given earthquake record in Volume I, right-adjusted in a three-digit numerical field. The second label is a string of three numbers separated by periods; the first number

gives the year in which the earthquake occurred, the second is the serial number of the record as it was received at the Caltech Earthquake Engineering Research Laboratory during that year, and the last number indicates whether it was a main event or an aftershock (sequentially numbered, the main event starting from zero). On the linear spectrum plot, the data lying above the 95 percent confidence level may be considered relevant to that degree. The spectra have been plotted up to a frequency of 25 cyc/sec on linear and logarithmic scales, corresponding to the capabilities of the instrumentation and data processing methods used.

A reproduction of the corrected digitized version of the acceleration - time record corresponding to each spectrum plot appears in Volume II, Part B, Report No. EERL 72-50.

The spectral data are stored on magnetic tape, copies of which are available on request from the National Information Service for Earthquake Engineering at the California Institute of Technology.

This report is the first of the Volume IV reports to present spectra of accelerograms recorded simultaneously at two different locations in the same building, viz. IVB022 and IVB023, Hollywood Storage Building, penthouse and basement, October 2, 1933. At present it is planned to calculate frequency response functions, involving smoothing and calculating the ratio of two such spectra, in supplementary reports.

The cooperative efforts of many people are essential in the preparation of a series of reports of this kind and we have been fortunate in the quality of staff that has carried out the various details with special care and attention. We should like to express our appreciation to

Mr. J. Justiss for his assistance with many details of computer programming, to the staff of the Willis H. Booth Computing Center for their continued help with all aspects of the computing process, and to the staff of the Caltech Graphic Arts Facilities for very efficient work on publication details. The whole project has been made possible by the continued support of the National Science Foundation, supplemented in an important way by contributions from the Earthquake Research Affiliates program of the California Institute of Technology.

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California Institute of Technology

INDEX OF EARTHQUAKE RECORDS IN
VOLUME IV, PART B

	<u>Page</u>
Long Beach Earthquake, March 10, 1933 - 1754 PST IVB021; Vernon CMD Bldg.; N08E, S82E, Up	12
Southern California Earthquake, October 2, 1933 - 0110 PST IVB022; Hollywood Storage Bldg., Penthouse; South, West, Up	18
IVB023; Hollywood Storage Bldg., Basement; South, East, Up	24
Lower California Earthquake, December 30, 1934 - 0552 PST IVB024; El Centro, Imperial Valley; North, East, Up	30
Helena, Montana Earthquake, October 31, 1935 - 1138 MST IVB025; Helena, Montana, Carroll College; North, East, Up	36
1st Northwest California Earthquake, September 11, 1938 - 2210 PST IVB026; Ferndale City Hall; S45W, N45W, Up	42
2nd Northwest California Earthquake, February 9, 1941 - 0145 PST IVB027; Ferndale City Hall; S45W, N45W, Up	48
Western Washington Earthquake, April 13, 1949 - 1156 PST IVB028; Engineer's Office at Army Base; S02W, N88W, Up	54
IVB029; Olympia, Washington, Highway Test Lab; S04E, S86W, Up	60
Northern California Earthquake, September 22, 1952 - 0441 PST IVB030; Ferndale City Hall; S44W, N46W, Up	66
Wheeler Ridge, California Earthquake January 12, 1954 - 1534 PST IVB031; Taft Lincoln School Tunnel; N21E, S69E, Up	72
Puget Sound, Washington Earthquake, April 29, 1965 - 0728 PST IVB032; Olympia, Washington Highway Test Lab; S04E, S86W, Up	78
Parkfield, California Earthquake, June 27, 1966 - 2026 PST IVB033; Cholame, Shandon, California, Array No. 2; N65E, - , Down	84
IVB034; Cholame, Shandon, California, Array No. 5; N05W, N85E, Down	88
IVB035; Cholame, Shandon, California, Array No. 8; N50E, N40W, Down	94

	<u>Page</u>
IVB036; Cholame, Shandon, California, Array No. 12; N50E, N40W, Down	100
IVB037; Temblor, California No. 2; N65W, S25W, Down	106
IVB038; San Luis Obispo, California, Recreation Bldg.; N36W, S54W, Up	112
2nd Northern California Earthquake, December 10, 1967 - 0406 PST	
IVB039; Eureka Federal Bldg.; S11E, N79E, Down	118
Borrego Mountain Earthquake, April 8, 1968 - 1830 PST	
IVB040; San Onofre SCE Power Plant; N33E, N57W, Down	124

EARTHQUAKE DATA

<u>Date & Time</u>	<u>Location</u>	<u>Epicenter</u>	<u>Max. Intensity</u>	<u>Mag.</u>	<u>References (See Following Pages)</u>
Mar. 10, 1933, 1754 PST	Long Beach	33°35'N, 117°59'W	IX	6.3	11, 12, 18
Oct. 2, 1933, 0110 PST	Southern Calif.	33°47'N, 118°08'W	VI	5.4	19
Dec. 30, 1934, 0552 PST	Lower Calif.	32°12'N, 115°30'W	IX	6.5	18
Oct. 31, 1935, 1138 MST	Helena, Mont.	46°37'N, 111°58'W	VIII	6	13, 14, 15, 18
Sep. 11, 1938, 2210 PST	NW Calif.	40°18'N, 124°48'W	VI	5.5	
Feb. 9, 1941, 0145 PST	NW Calif.	40°54'N, 125°24'W	VI	6.6	
Apr. 13, 1949, 1156 PST	Western Wash.	47°06'N, 122°42'W	VIII	7.1	16, 17, 18
Sep. 22, 1952, 0441 PDT	Northern Calif.	40°12'N, 124°25'W	VII	5.5	
Jan. 12, 1954, 1534 PST	Wheeler Ridge, Calif.	35°00'N, 119°01'W	VIII	5.9	
Apr. 29, 1965, 0728 PST	Puget Sound, Wash.	47°24'N, 122°18'W	VII	6.5	
June 27, 1966, 2026 PST	Parkfield, Calif.	35°54'N, 120°54'W	VII	5.6	6, 7, 8, 9, 10
Dec. 10, 1967, 0406 PST	Northern Calif.	40°30'N, 124°36'W	VI	5.8	
Apr. 8, 1968, 1830 PST	Borrego Mtn.	33°09'N, 116°08'W	VII	6.5	2, 3, 4, 5

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Component Directions for Part A

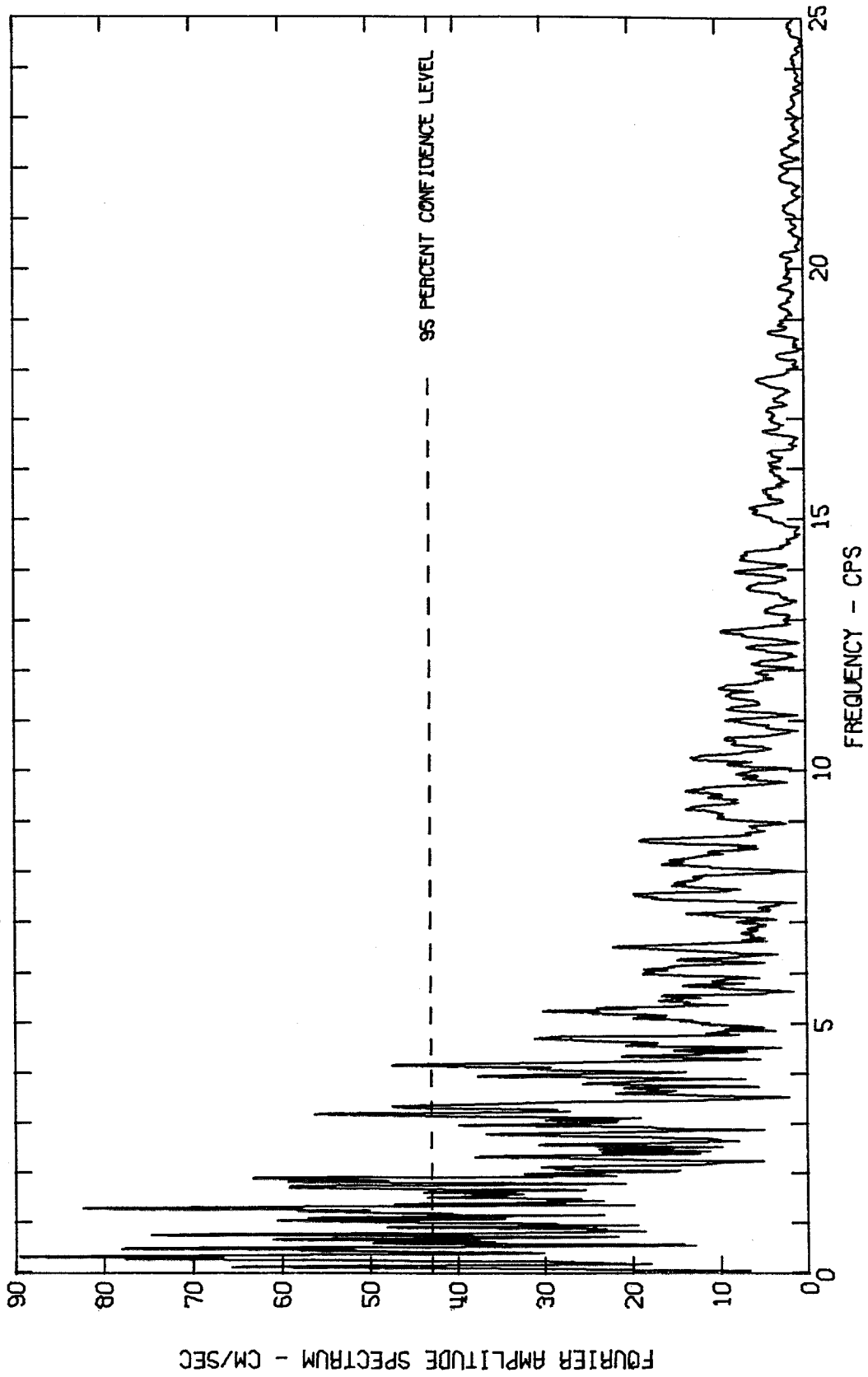
As mentioned in the Preface, there were some cases of incorrect component description in the records of Volume III, Part A. The following is a complete list of the components of the 20 records specifying the direction of transducer pendulum motion corresponding to a trace motion "up", or positive, on the record as normally viewed with time increasing from left to right.

<u>Record</u>	<u>Pendulum motion for trace "up"</u>
IVA001, El Centro, May 18, 1940	North, East, Up
IVA002, Ferndale, October 7, 1951	S44W, N46W, Up
IVA003, Pasadena, July 21, 1952	South, West, Up
IVA004, Taft, July 21, 1952	N21E, S69E, Up
IVA005, Santa Barbara, July 21, 1952	N42E, S48E, Up
IVA006, Hollywood Storage, Basement, July 21, 1952	South, East, Up
IVA007, Hollywood Storage, PE Lot July 21, 1952	South, East, Up
IVA008, Eureka, December 21, 1954	S11E*, N79E, Up
IVA009, Ferndale, December 21, 1954	S44W*, N46W, Up
IVA010, San Jose, B of A, Basement, September 4, 1955	S31E*, N59E, Up
IVA011, El Centro, February 9, 1956, 0633 PST	South, West, Up
IVA012, El Centro, February 9, 1956, 0725 PST	South, West, Up
IVA013, San Francisco, SP Building, Basement March 22, 1957	N45E, N45W, Up
IVA014, San Francisco, Alex Building, Basement March 22, 1957	N09W, N81E, Up

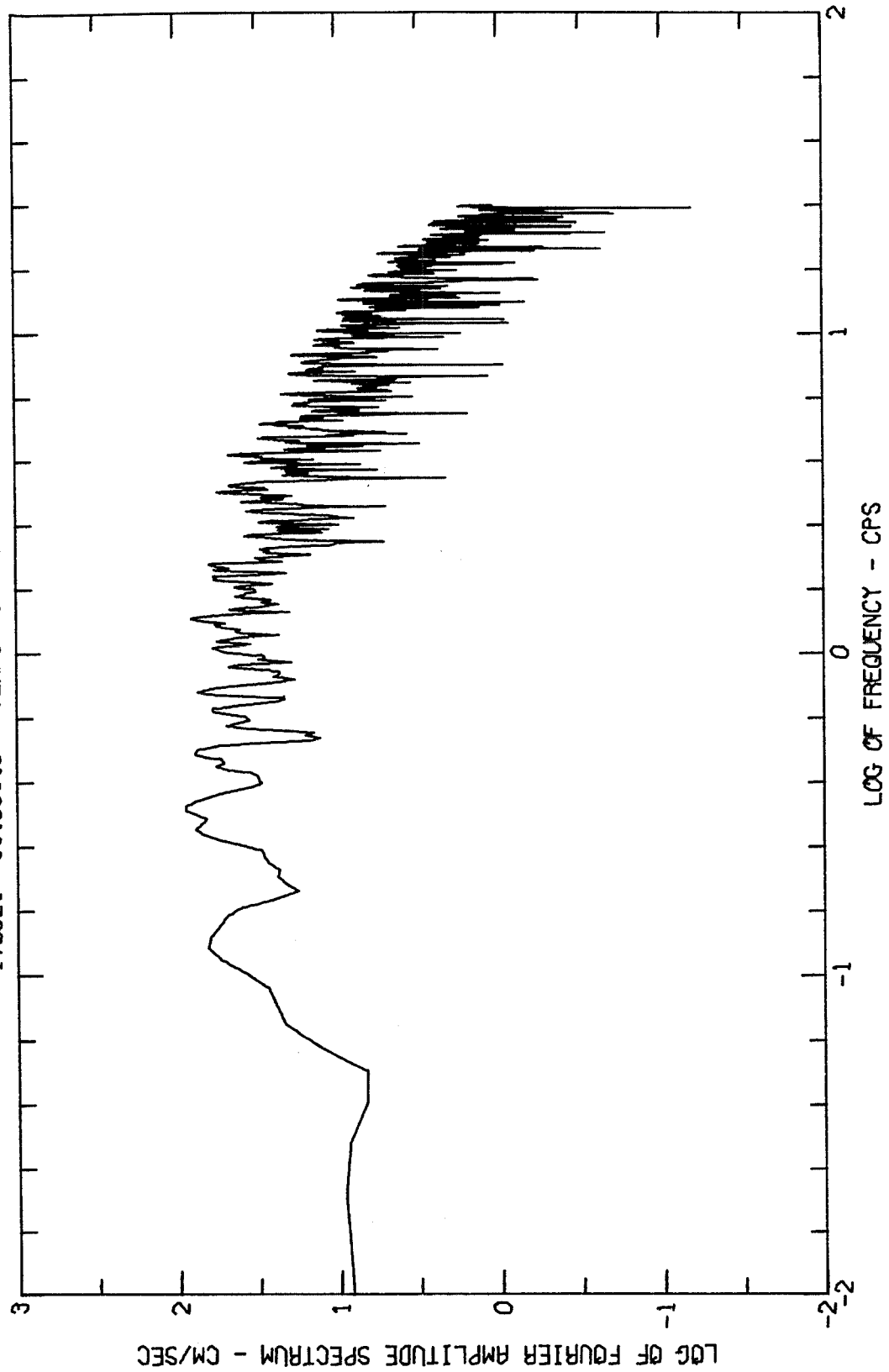
<u>Record</u>	<u>Pendulum motion for trace "up"</u>
IVA 015, San Francisco, Golden Gate Park, March 22, 1957	N10E, N80W, Up
IVA 016, San Francisco, State Building, March 22, 1957	N09W, N81E, Up
IVA 017, Oakland City Hall, Basement, March 22, 1957	N26E, S64E*, Up
IVA 018, Hollister, April 8, 1961	S01W, N89W, Up
IVA 019, El Centro, April 8, 1968	South, West, Up
IVA 020, San Diego, Light and Power Building April 8, 1968	South, East, Up

*These component directions are from "Strong Motion Instrumental Data,"
U. S. Coast and Geodetic Survey, ESSA, January, 1970, revising the entry
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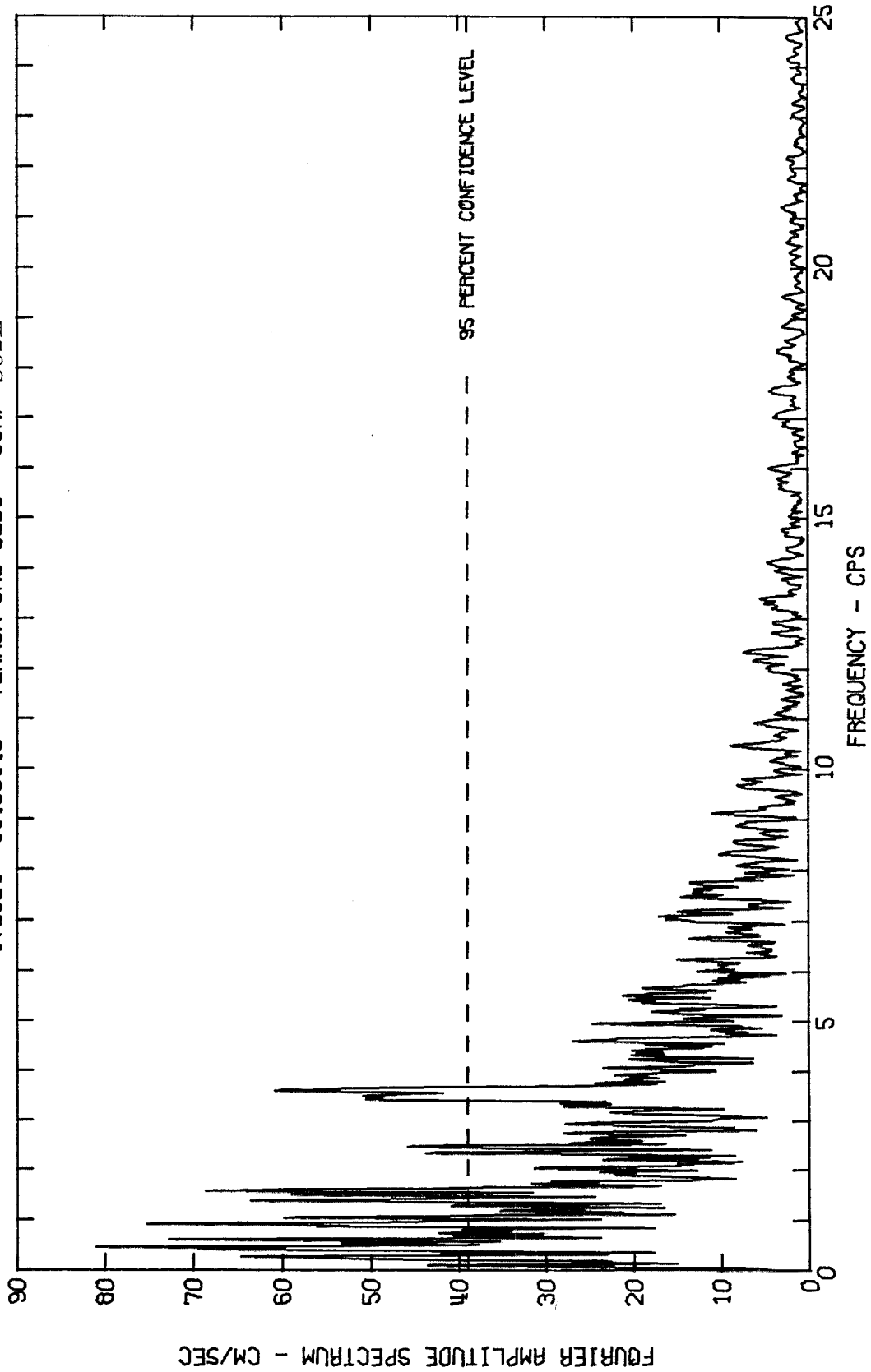
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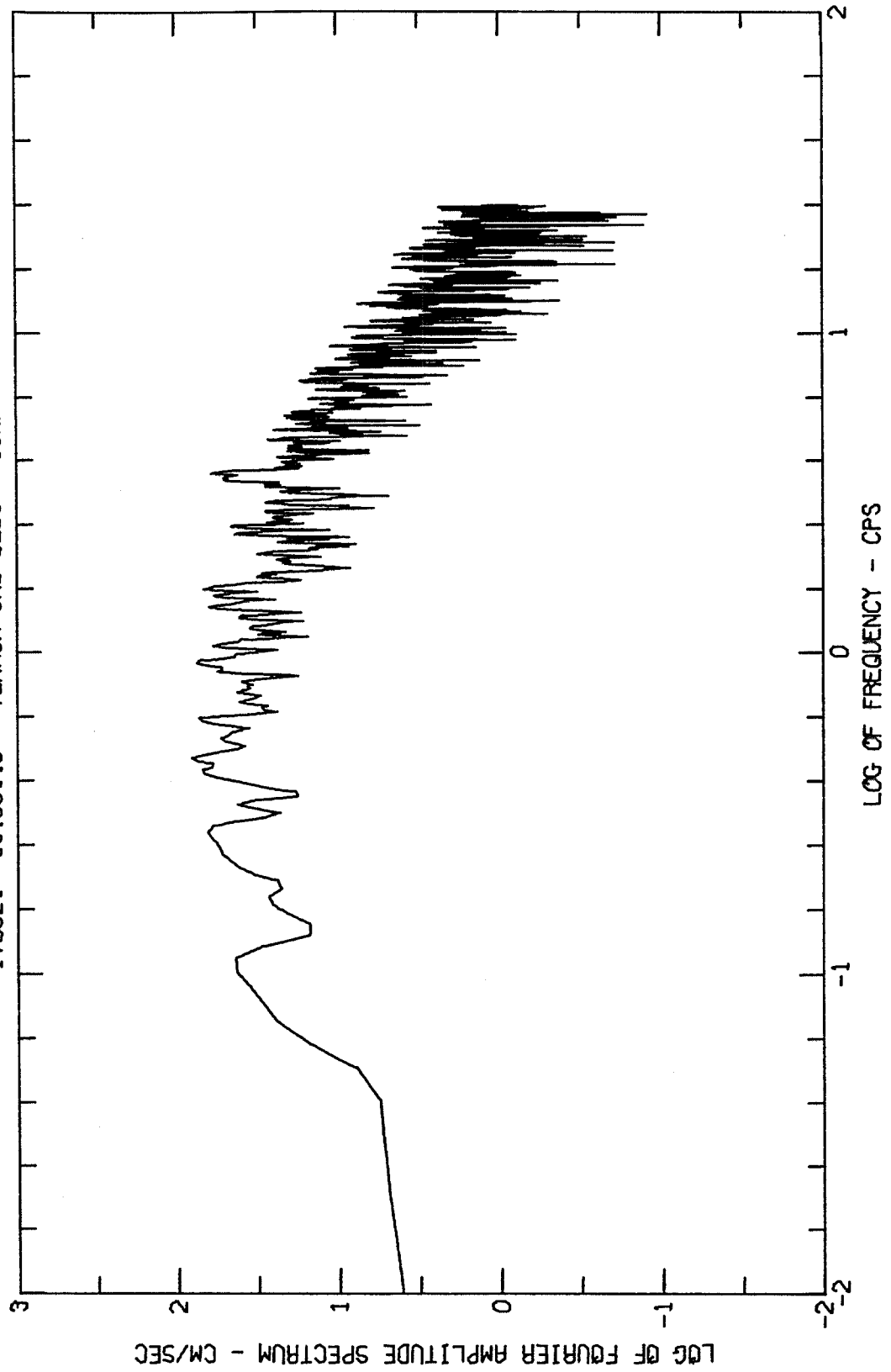
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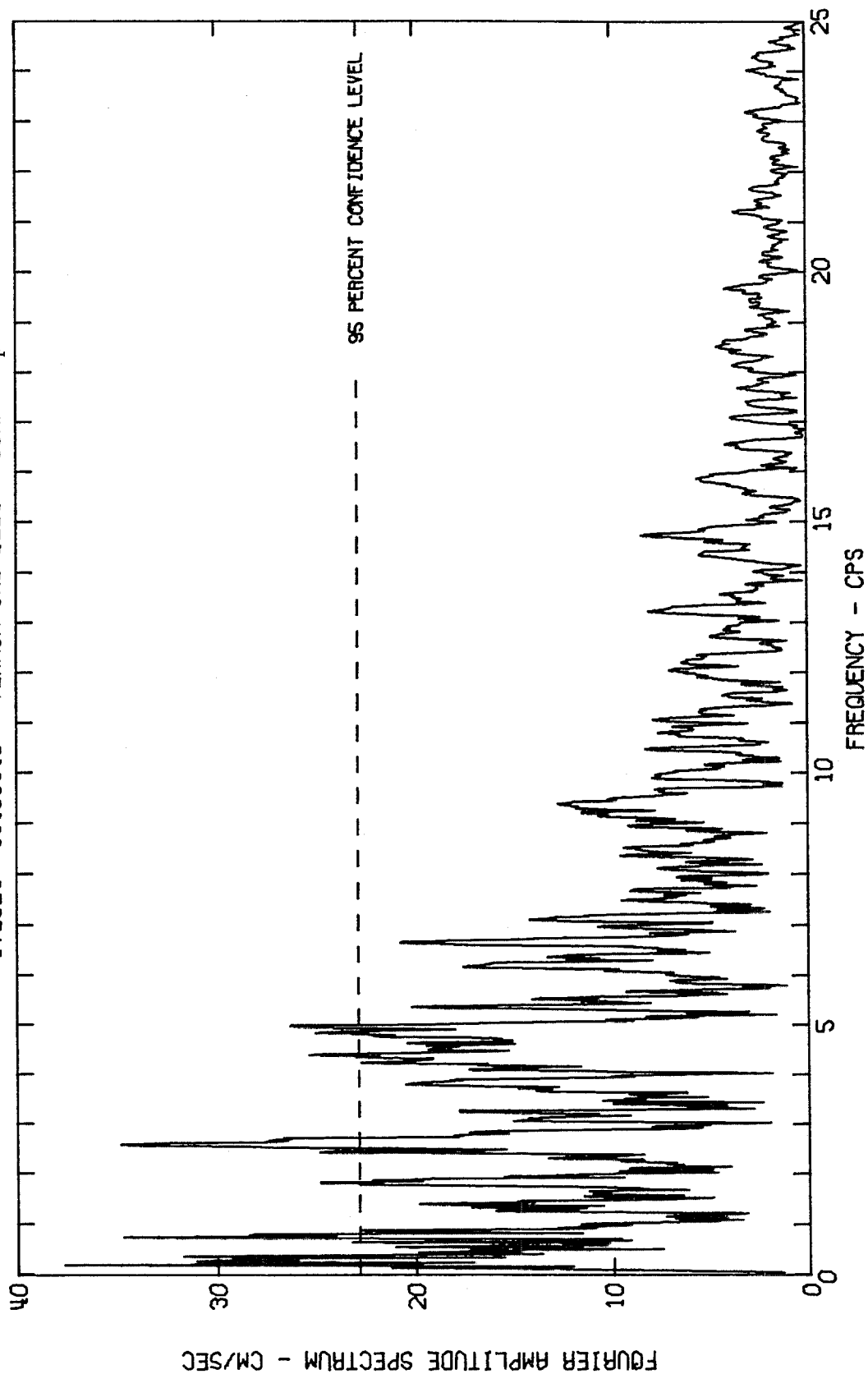
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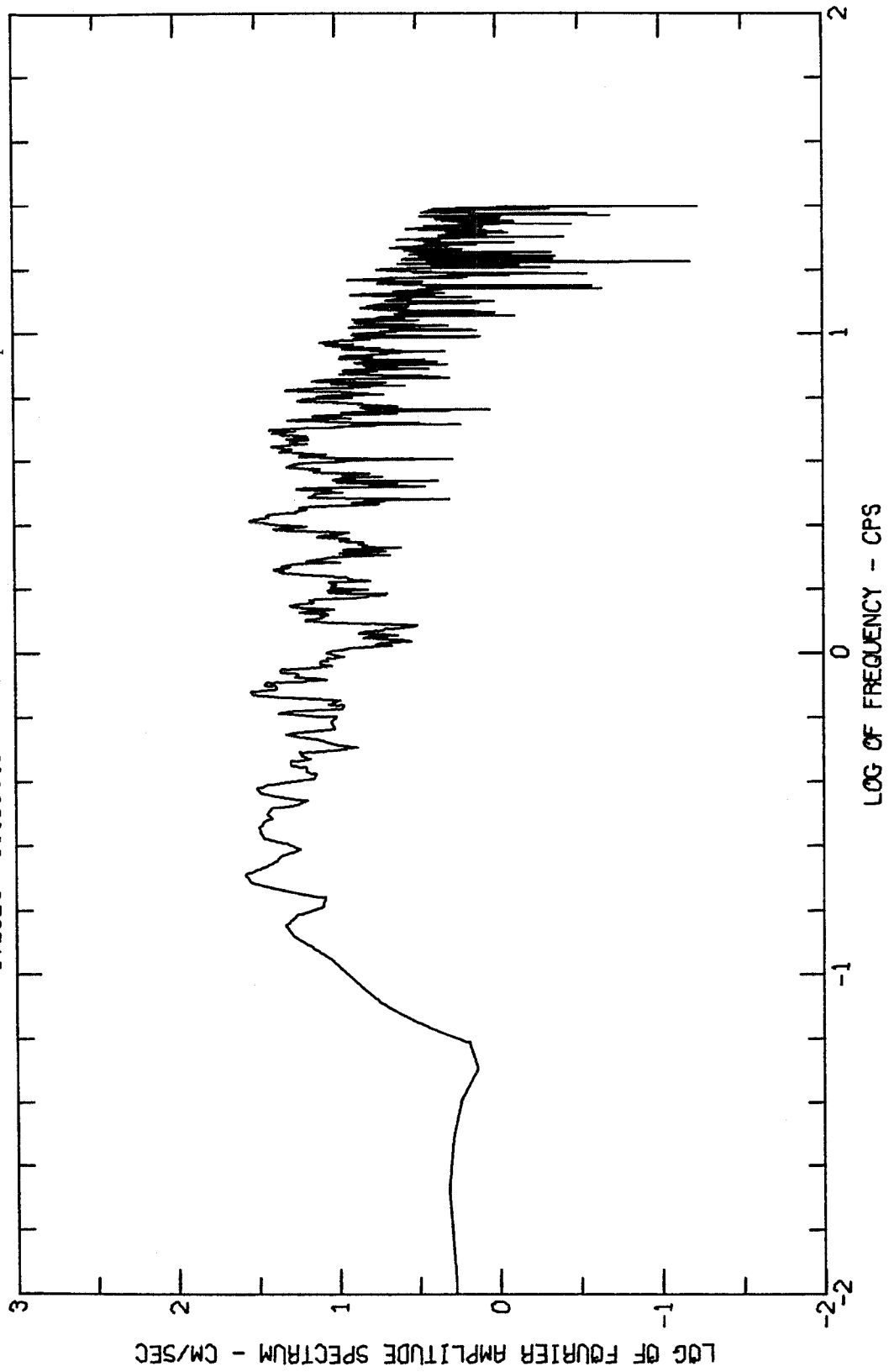
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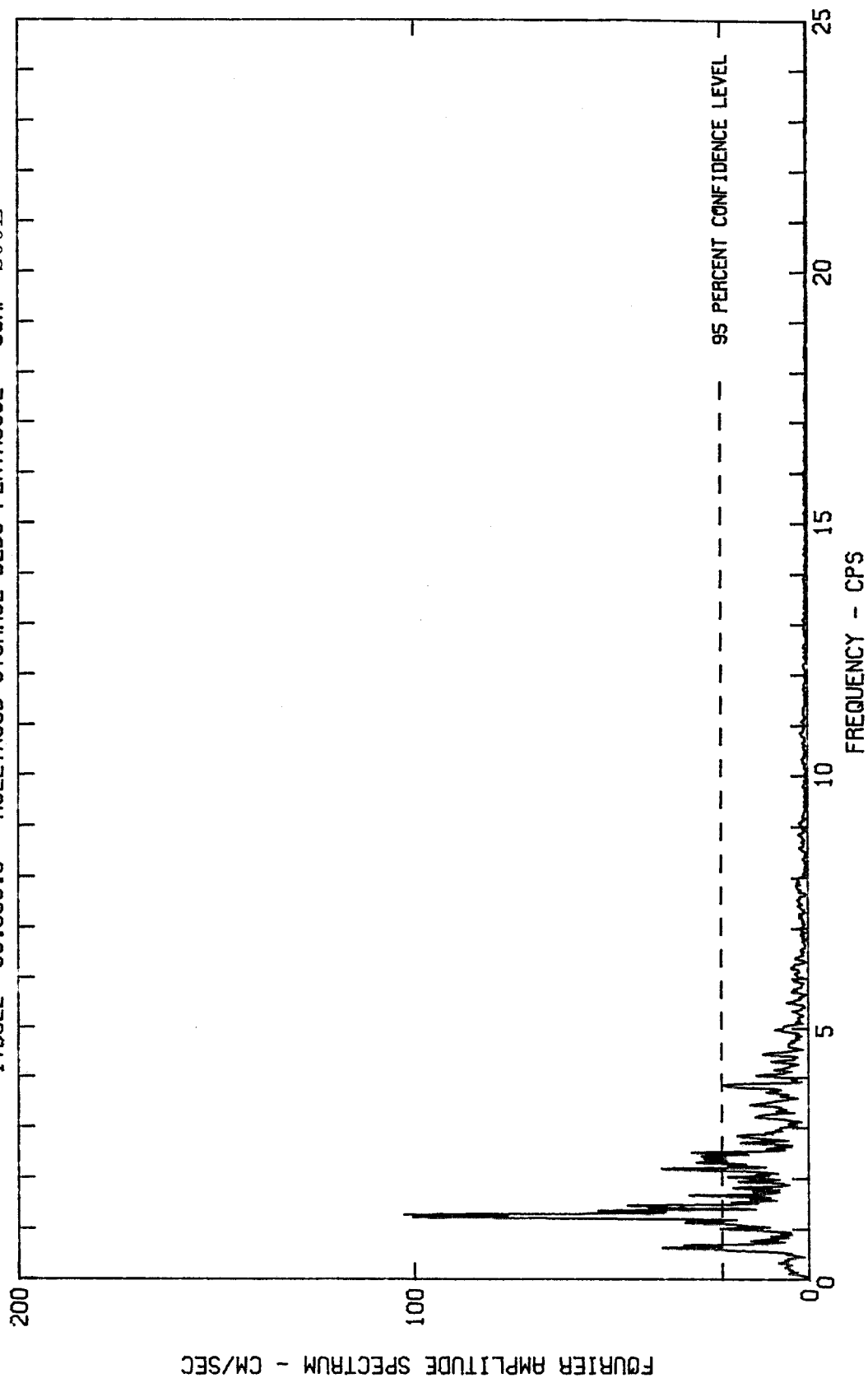
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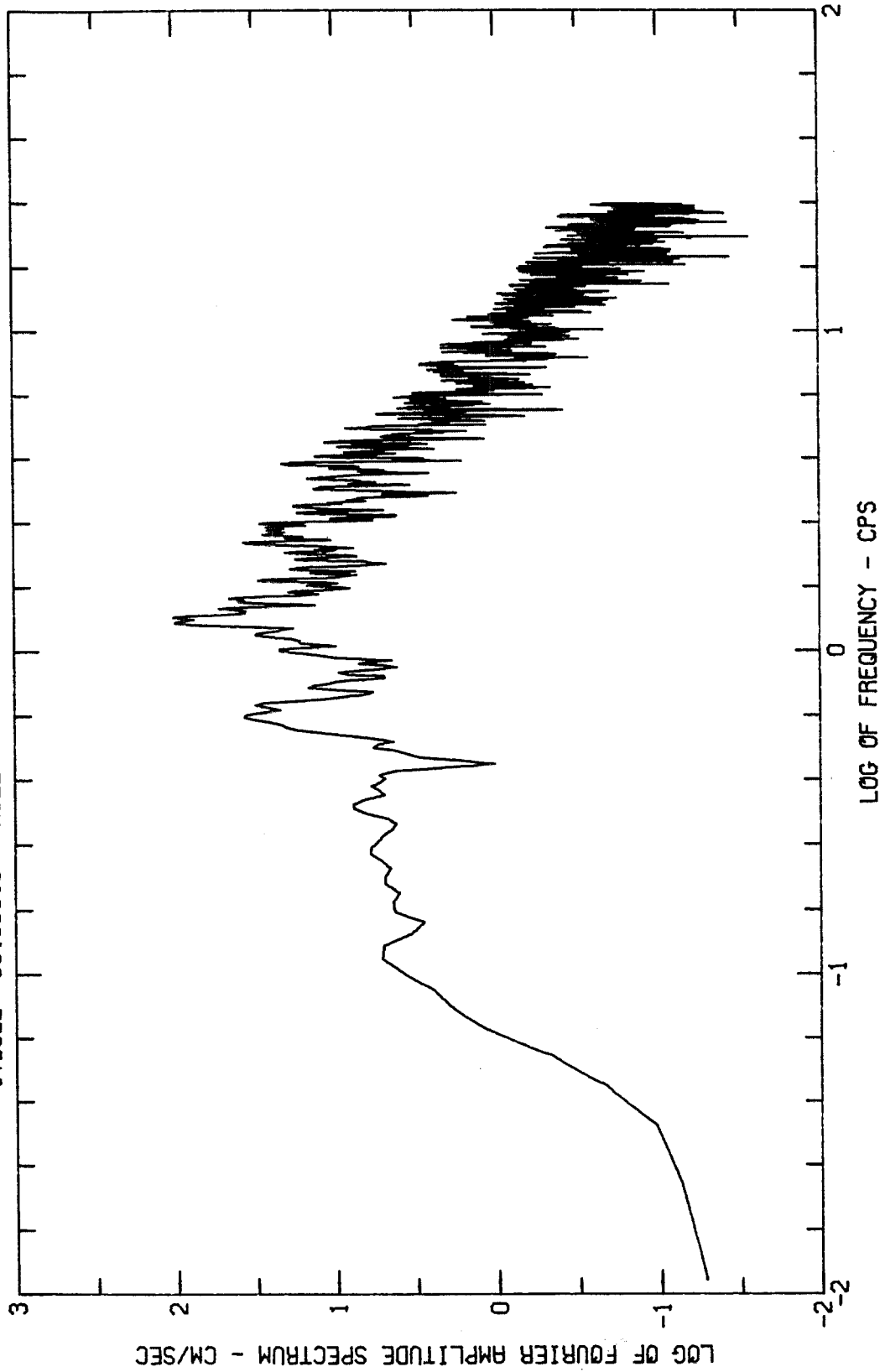
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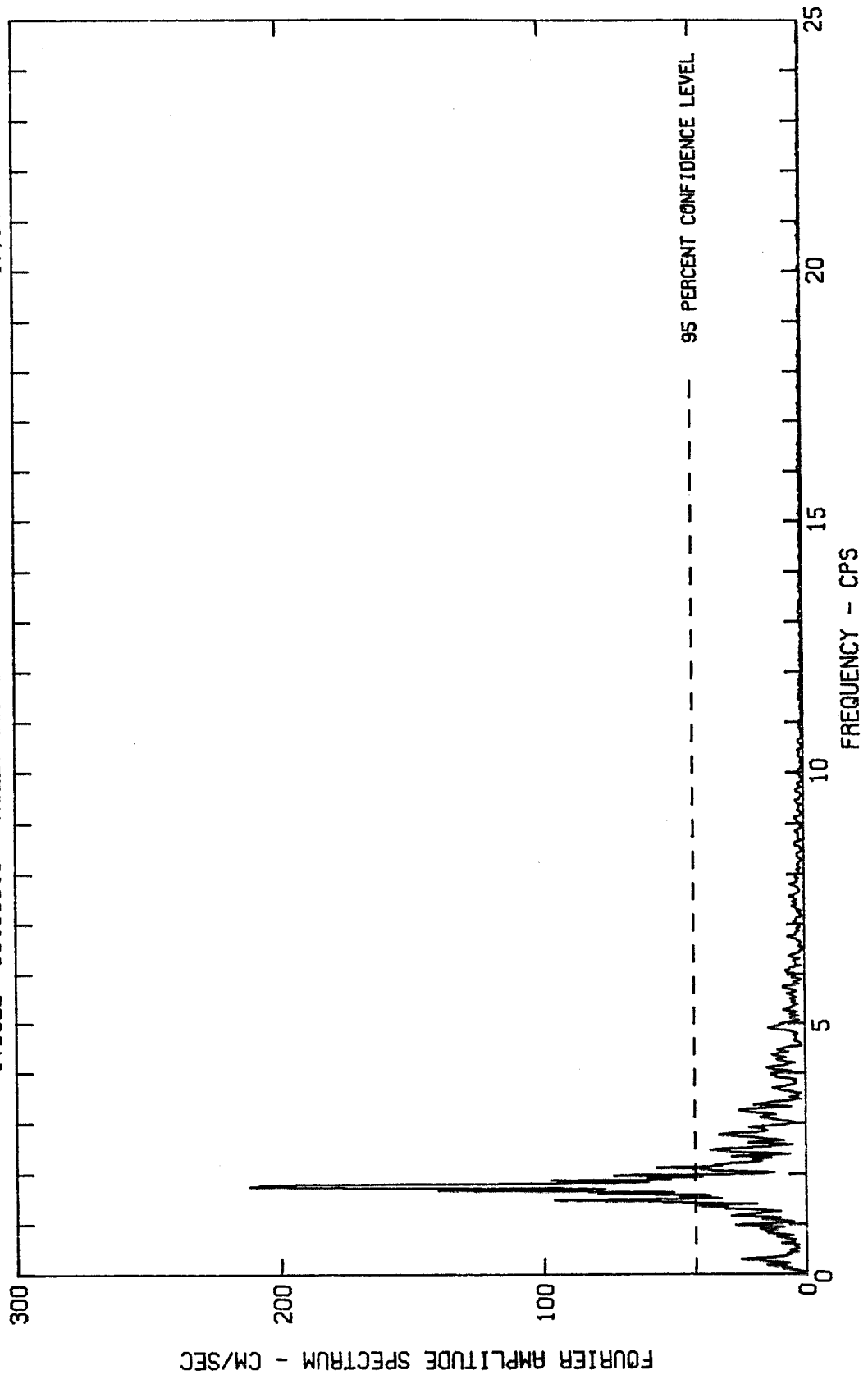
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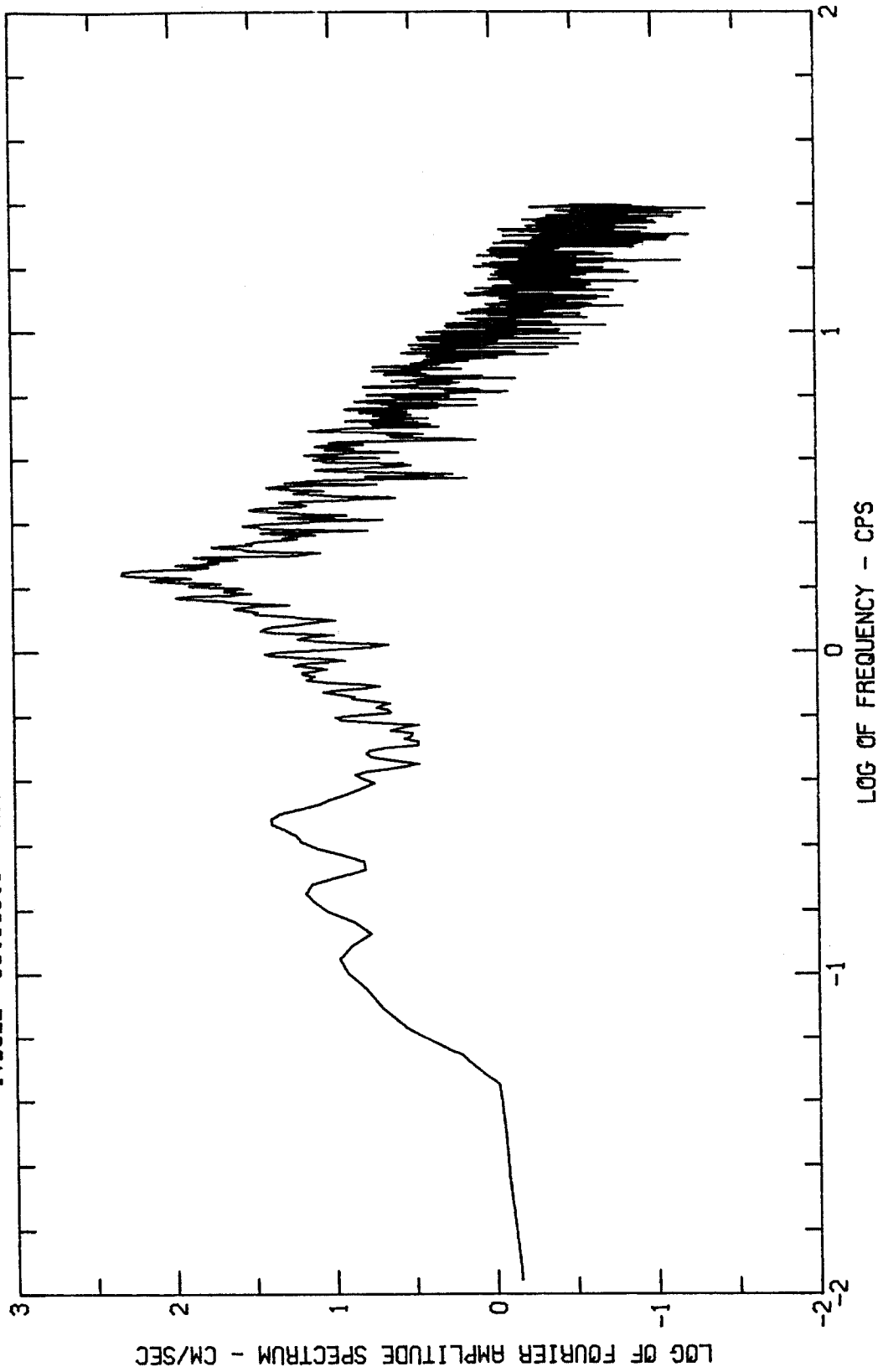
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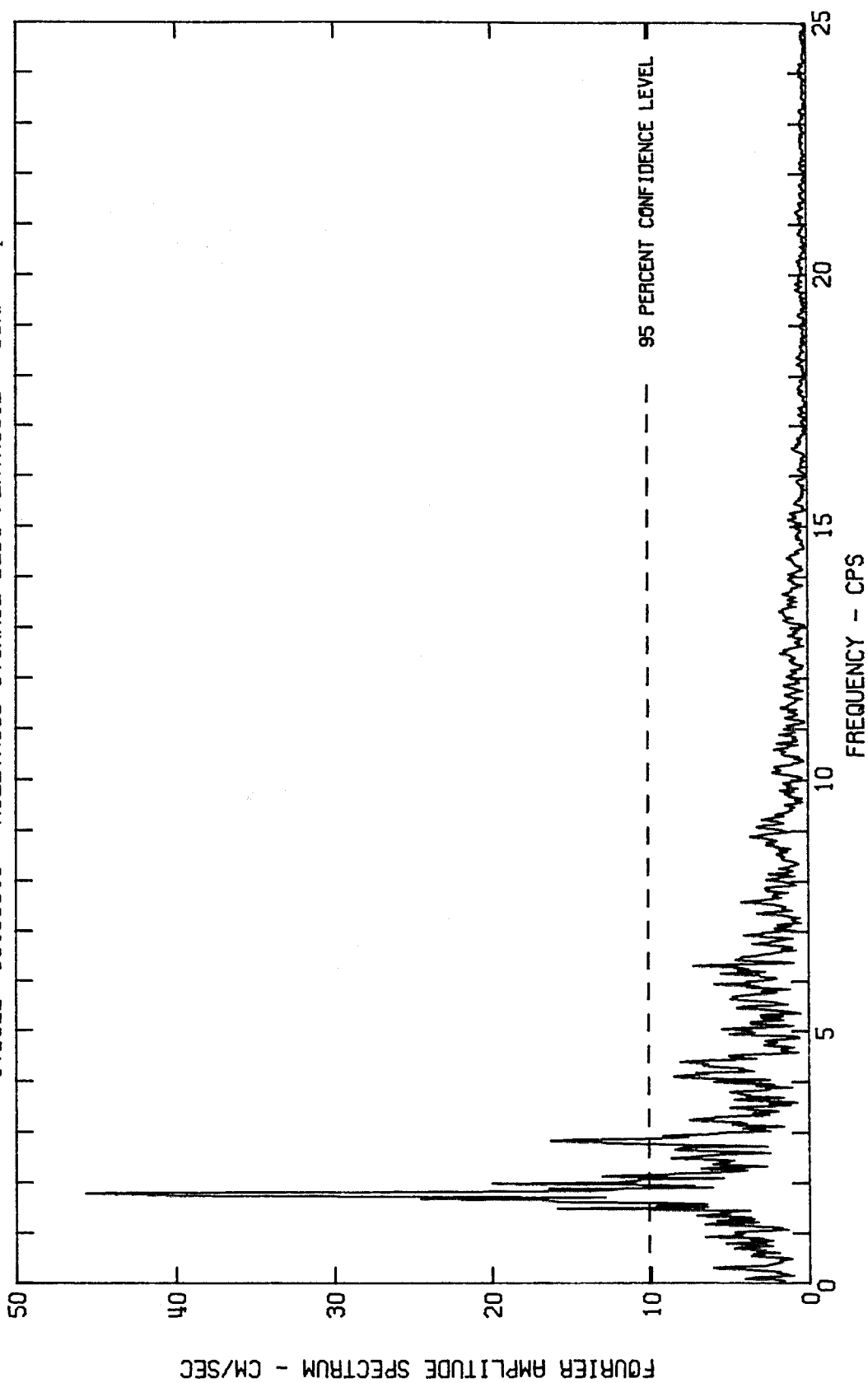
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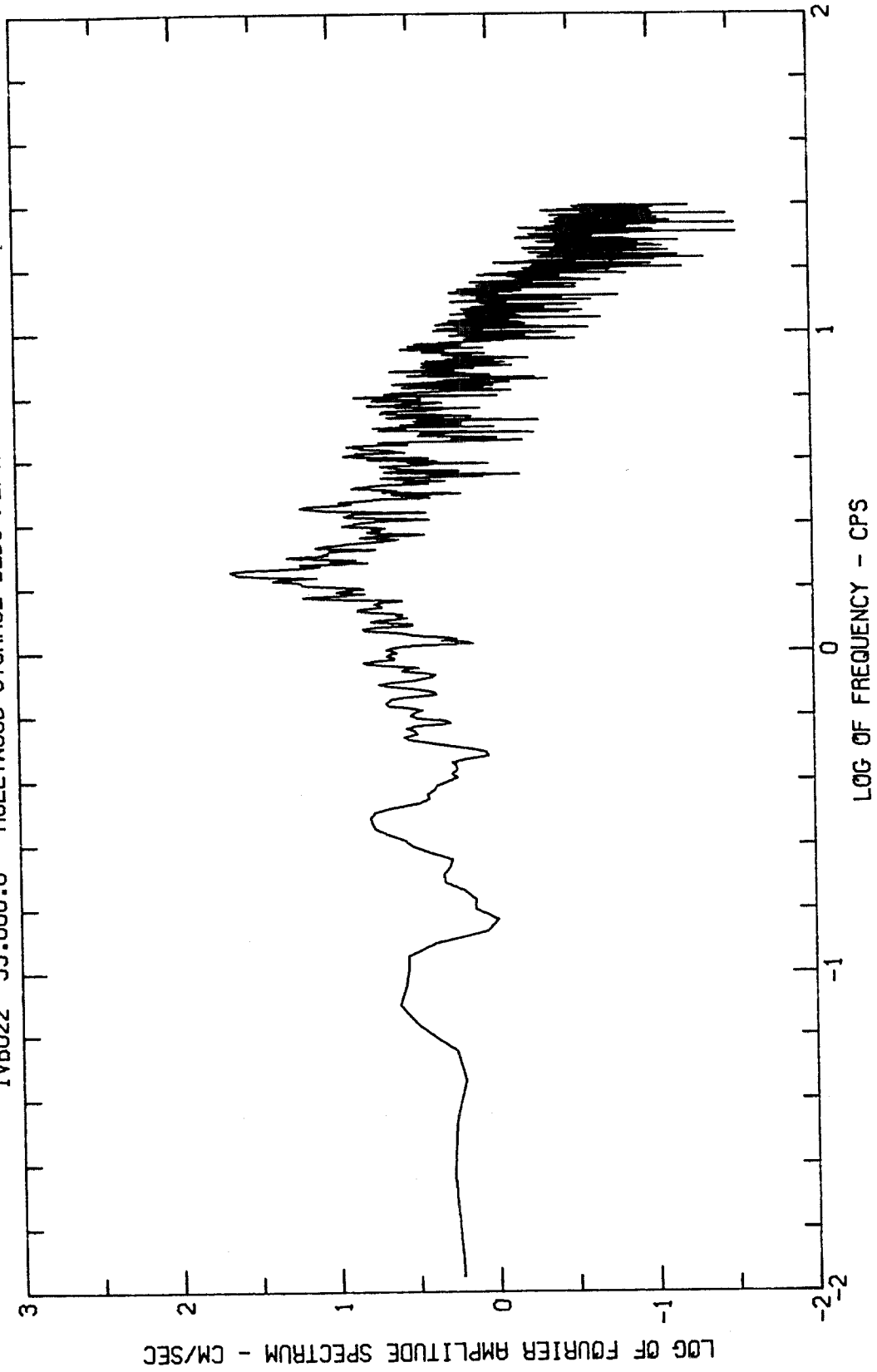
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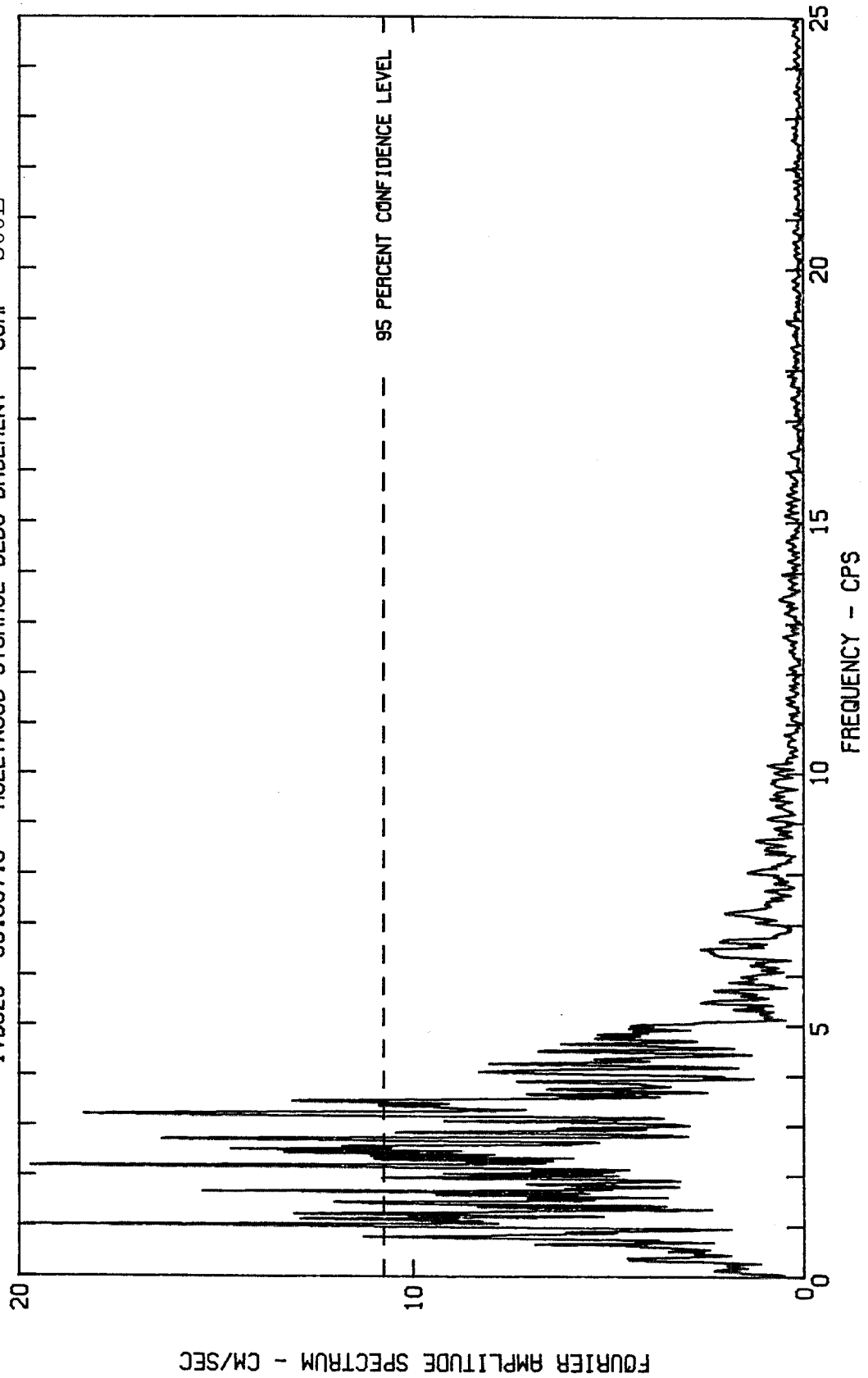
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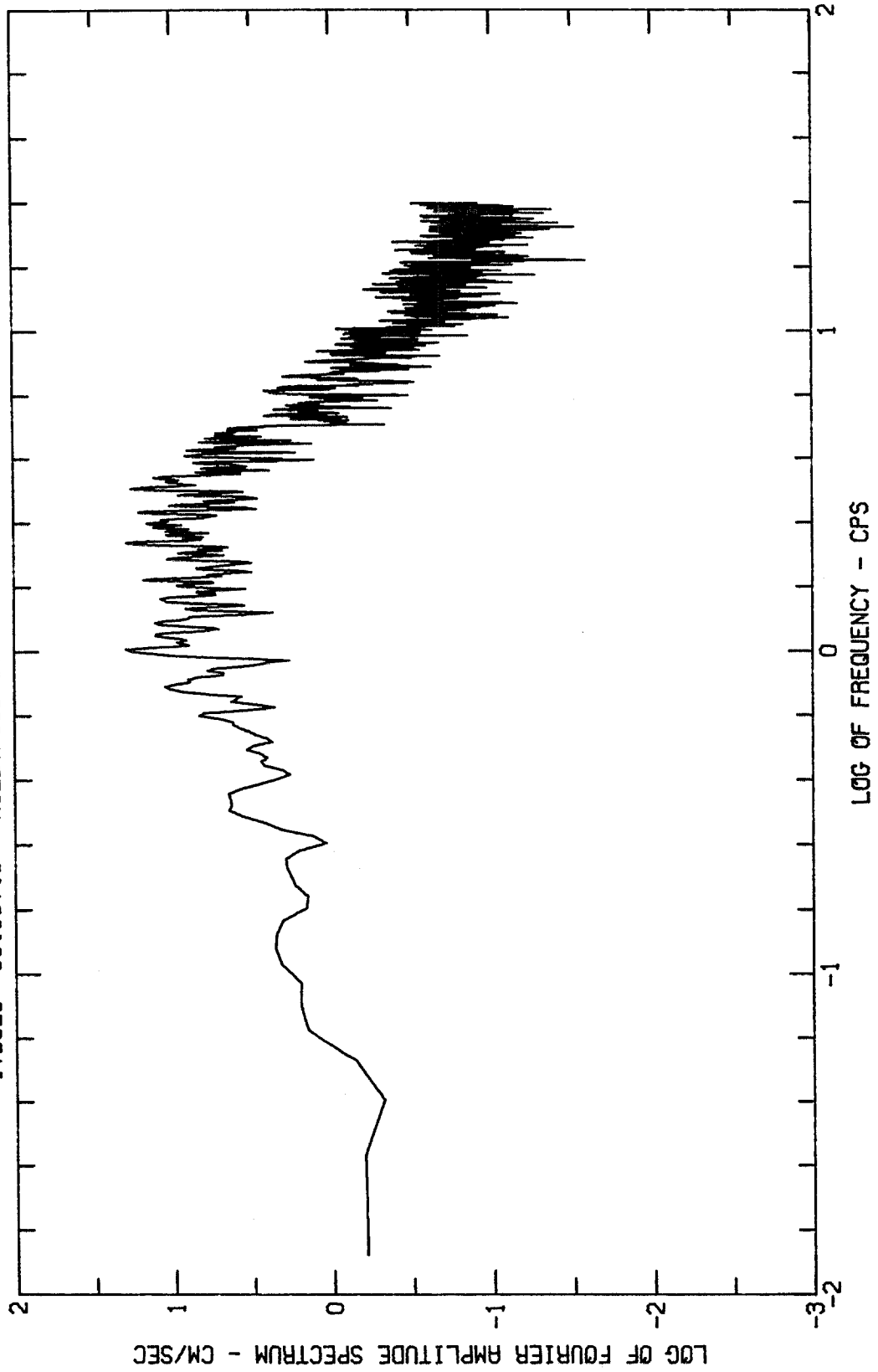
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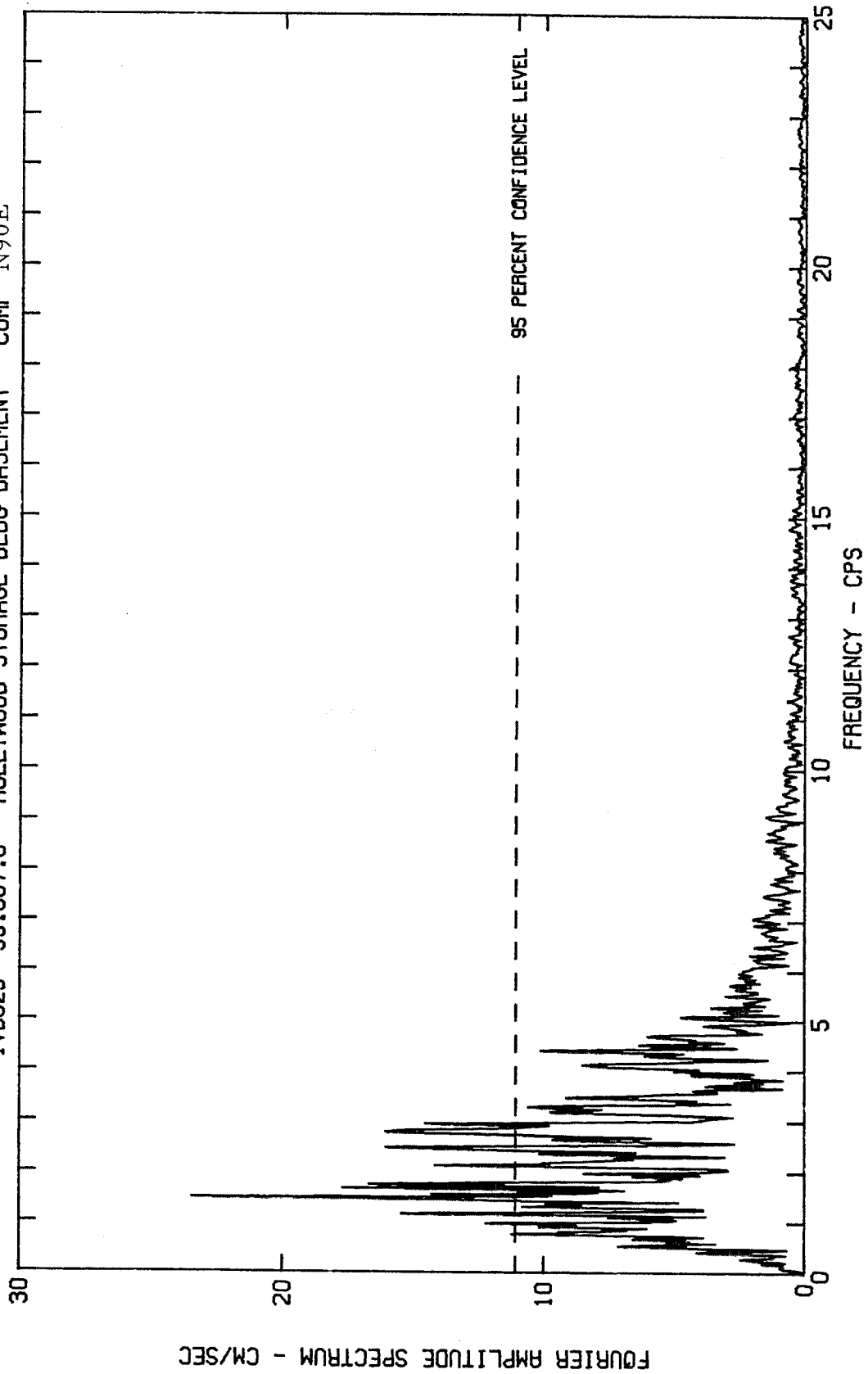
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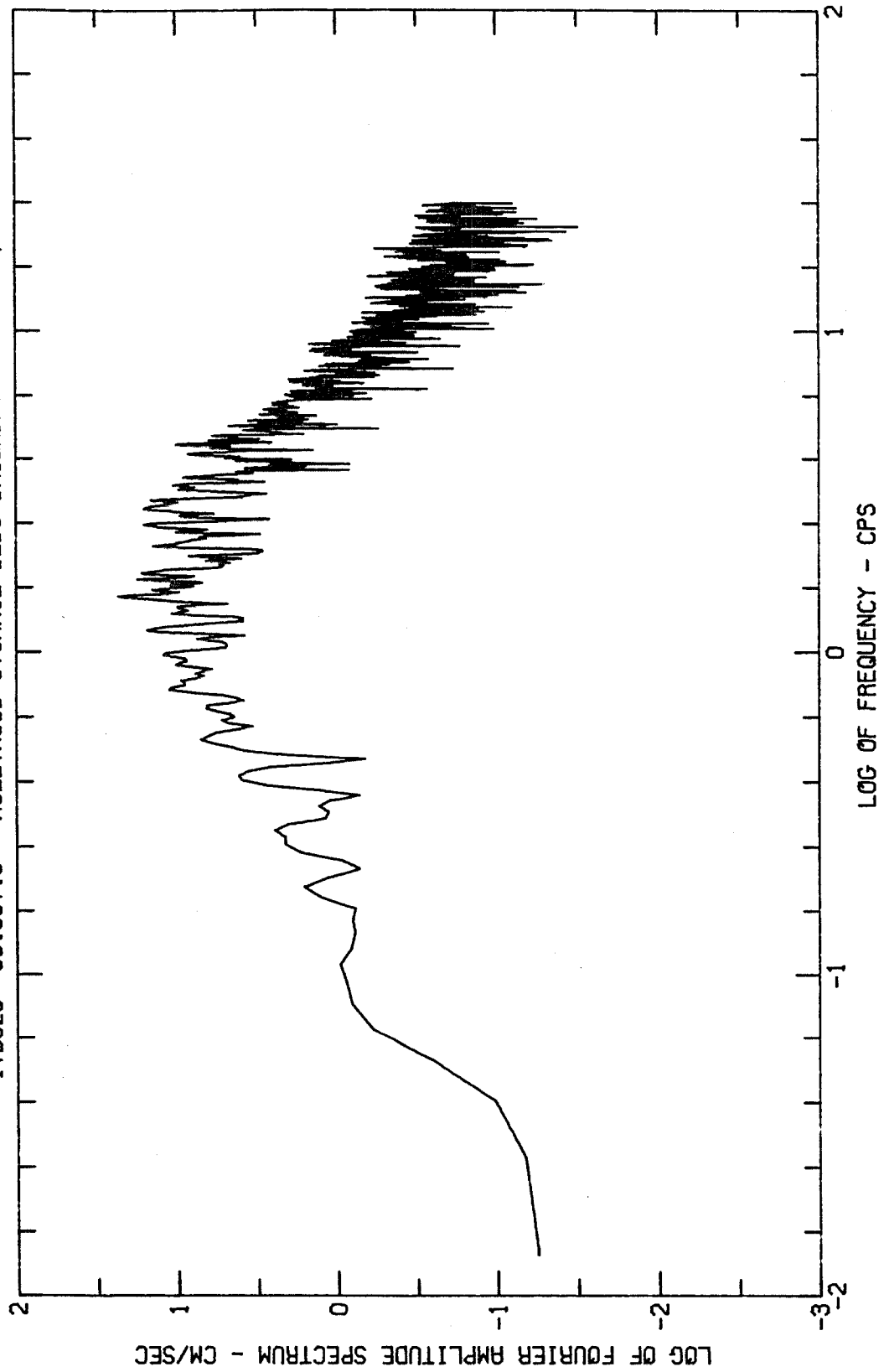
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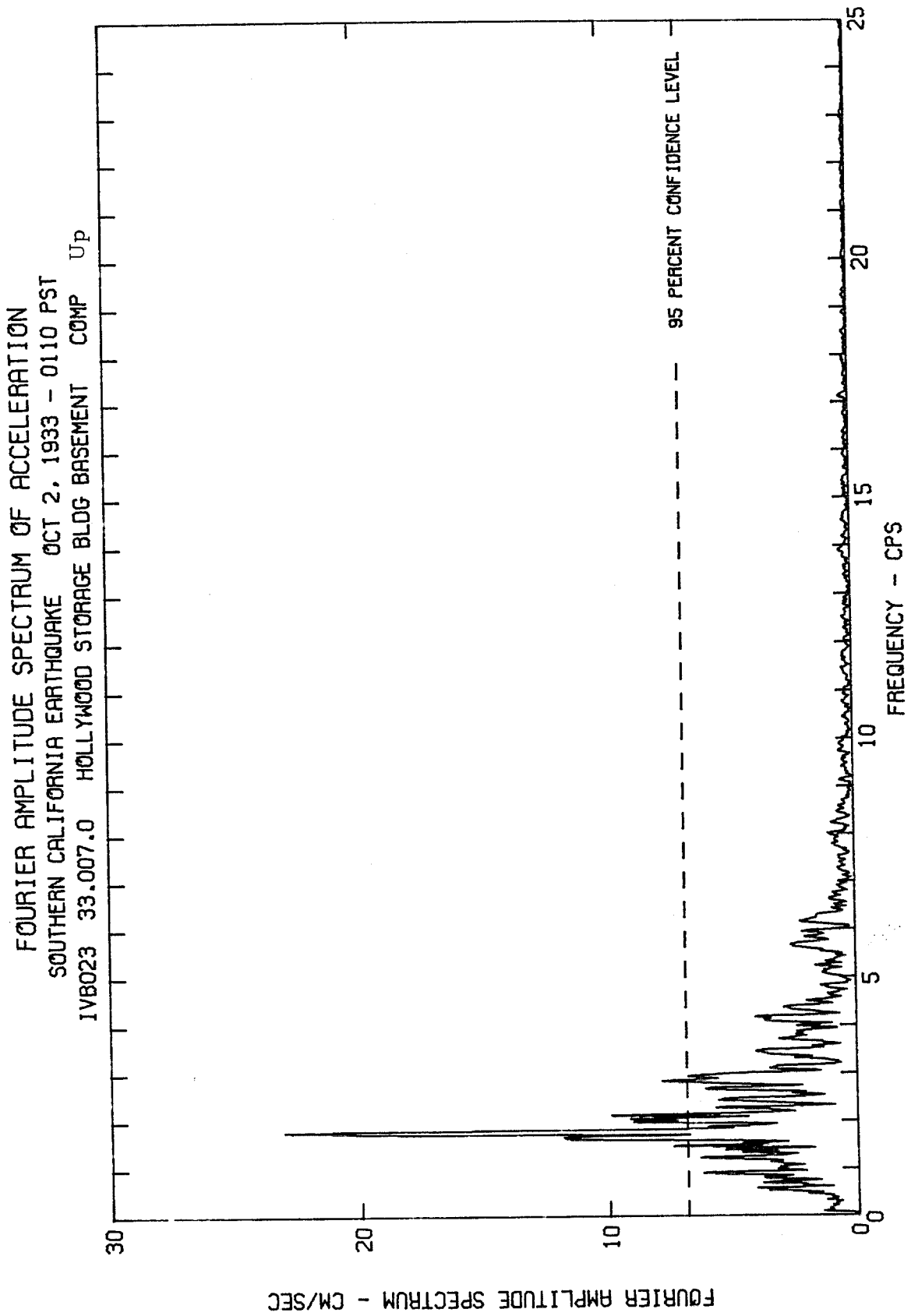


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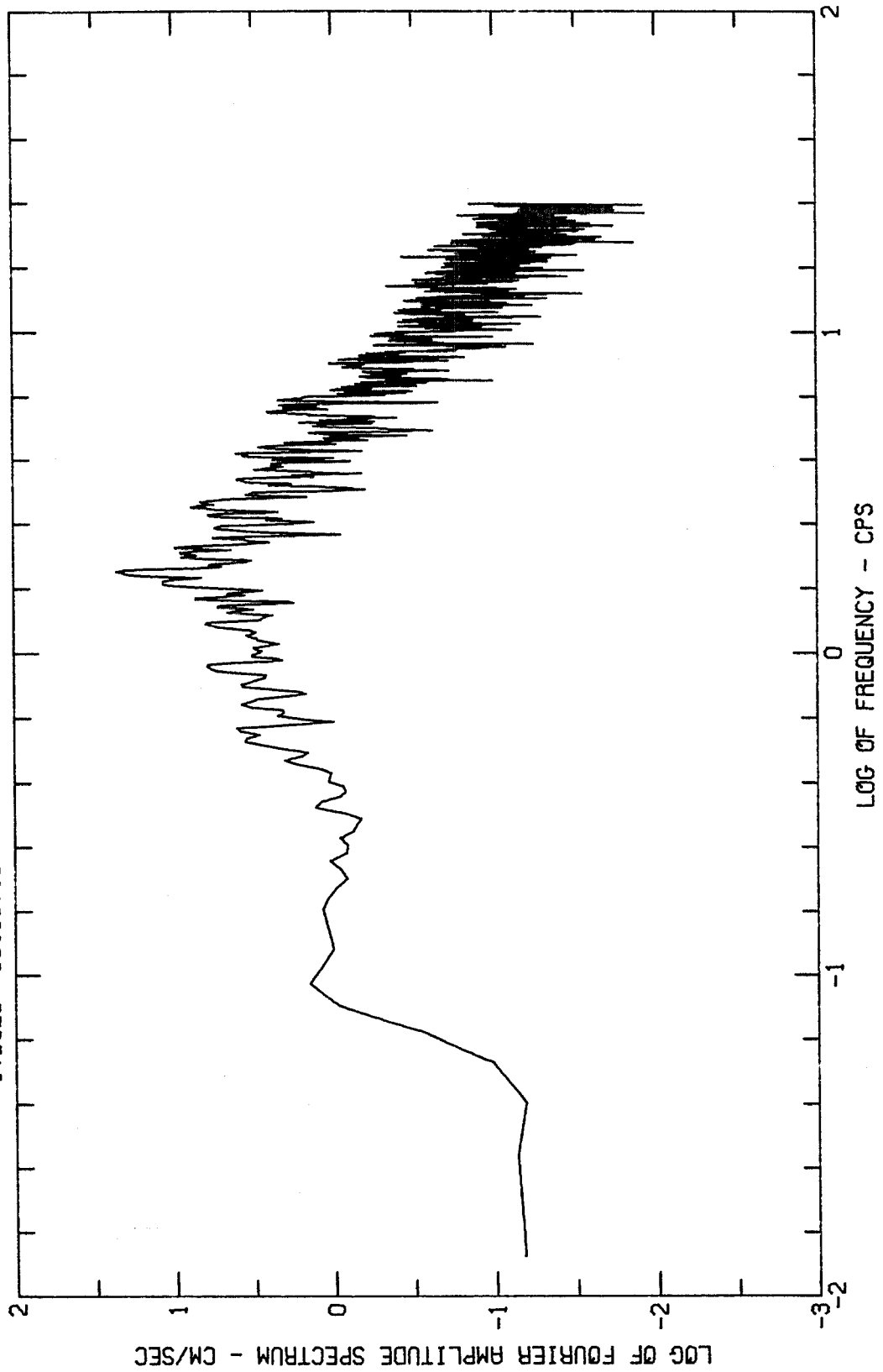


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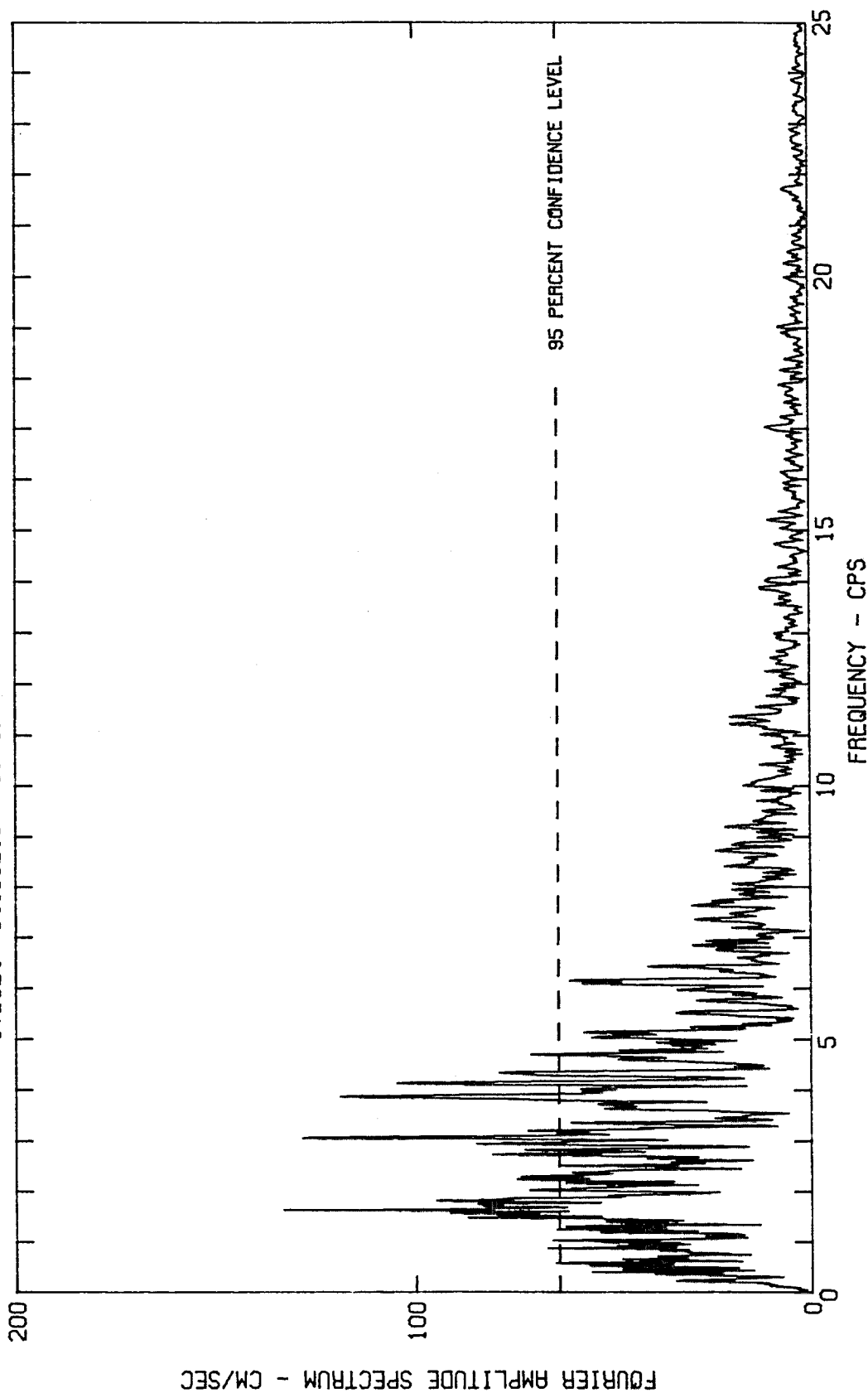




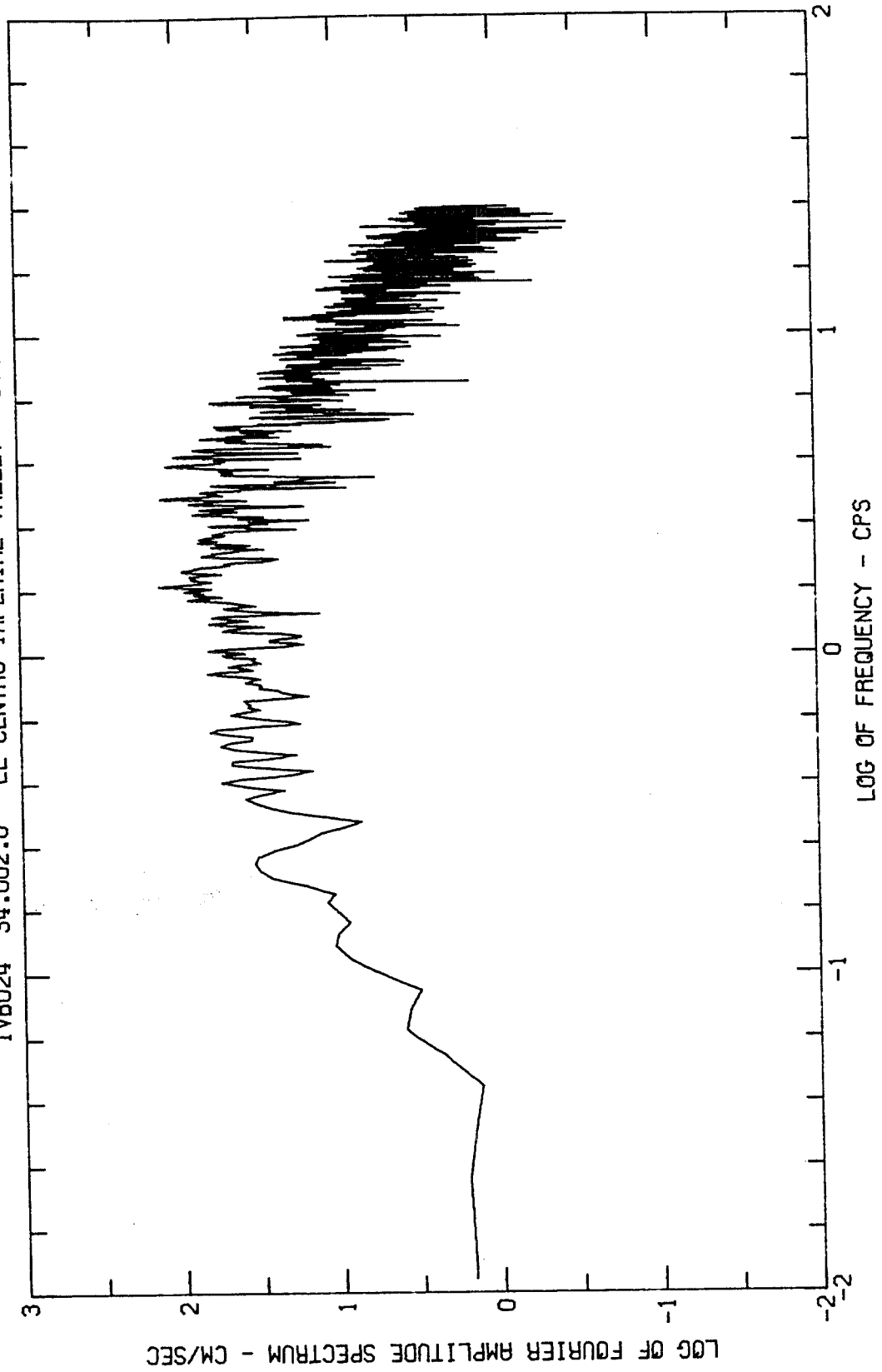
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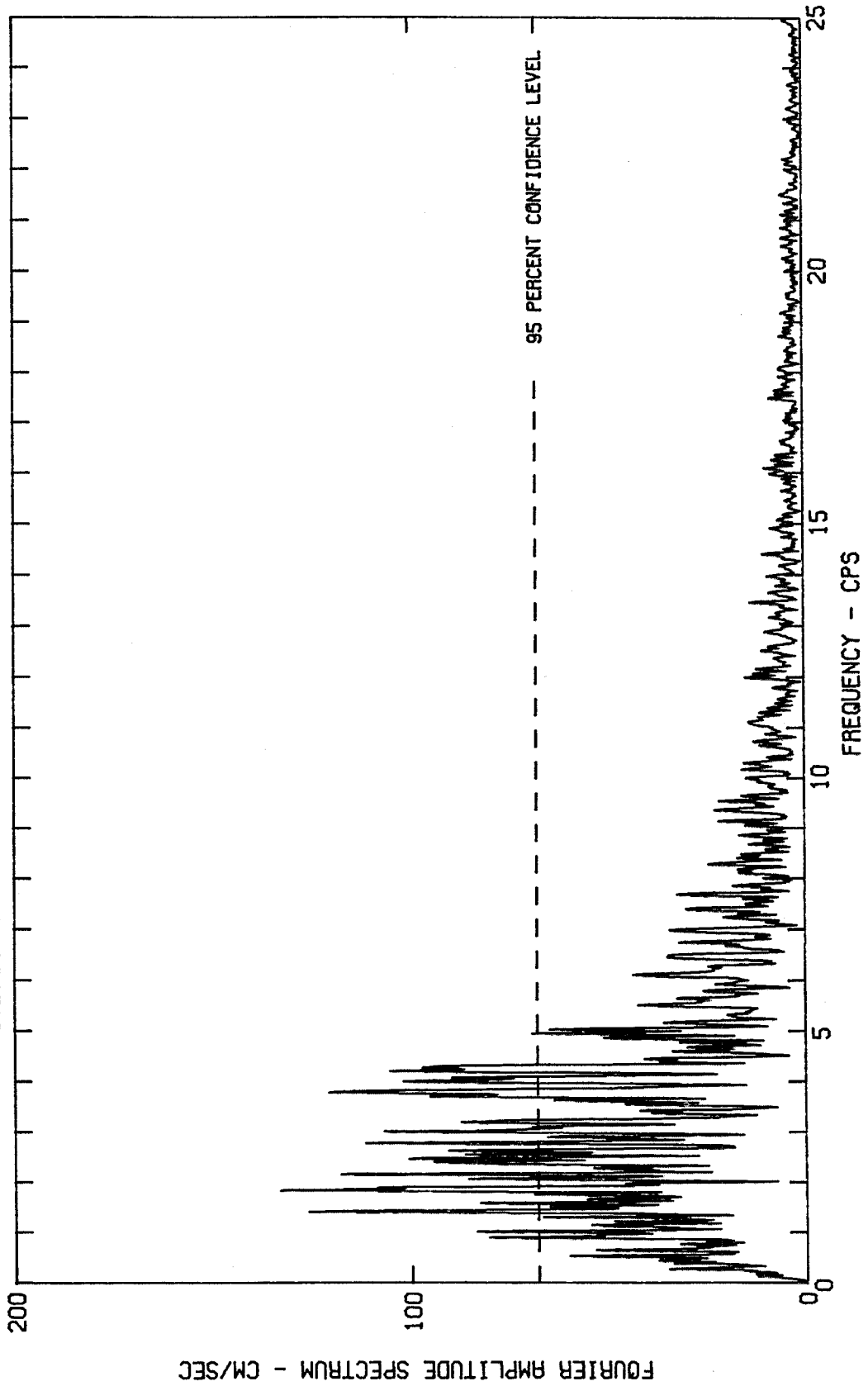
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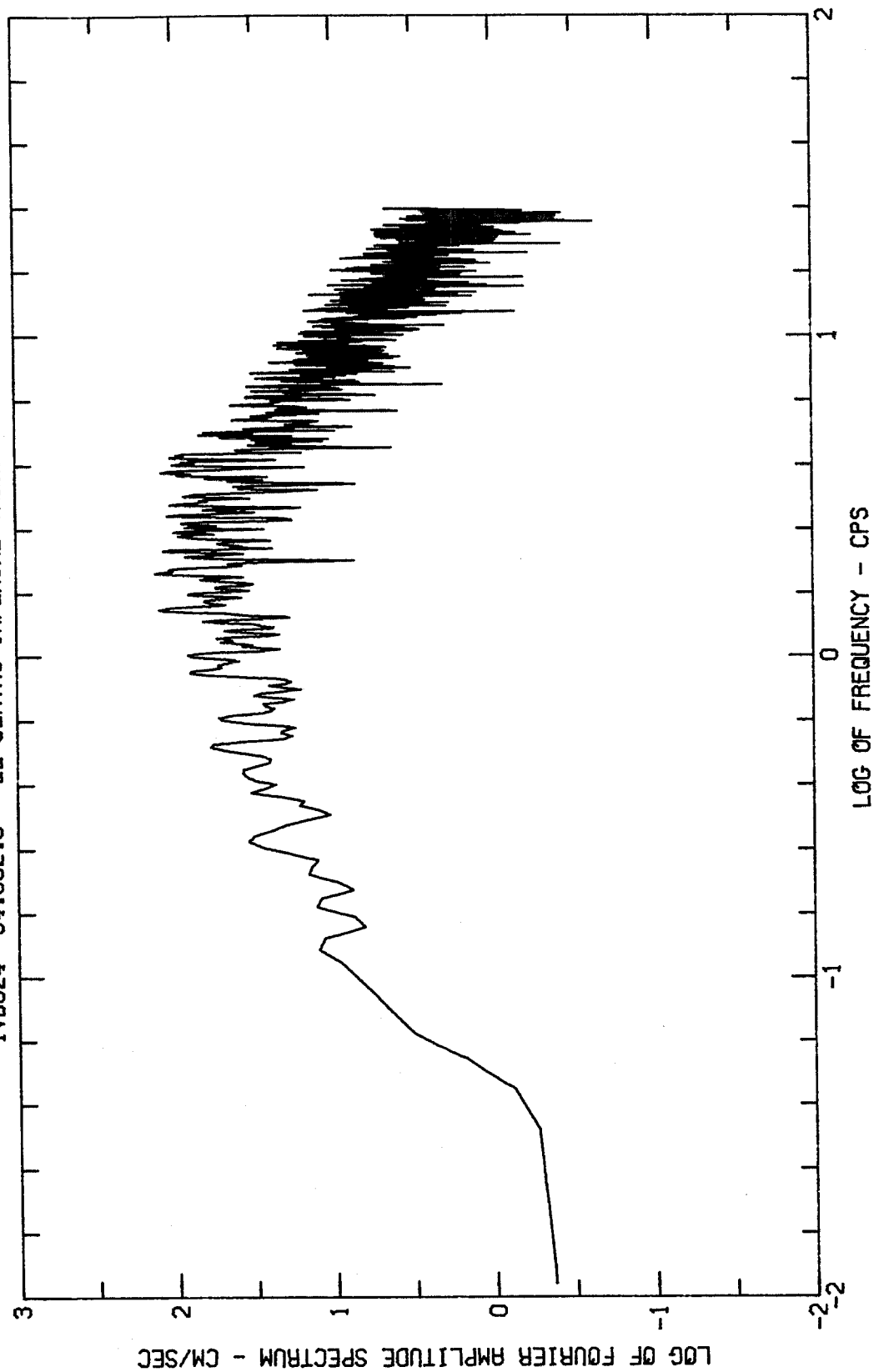
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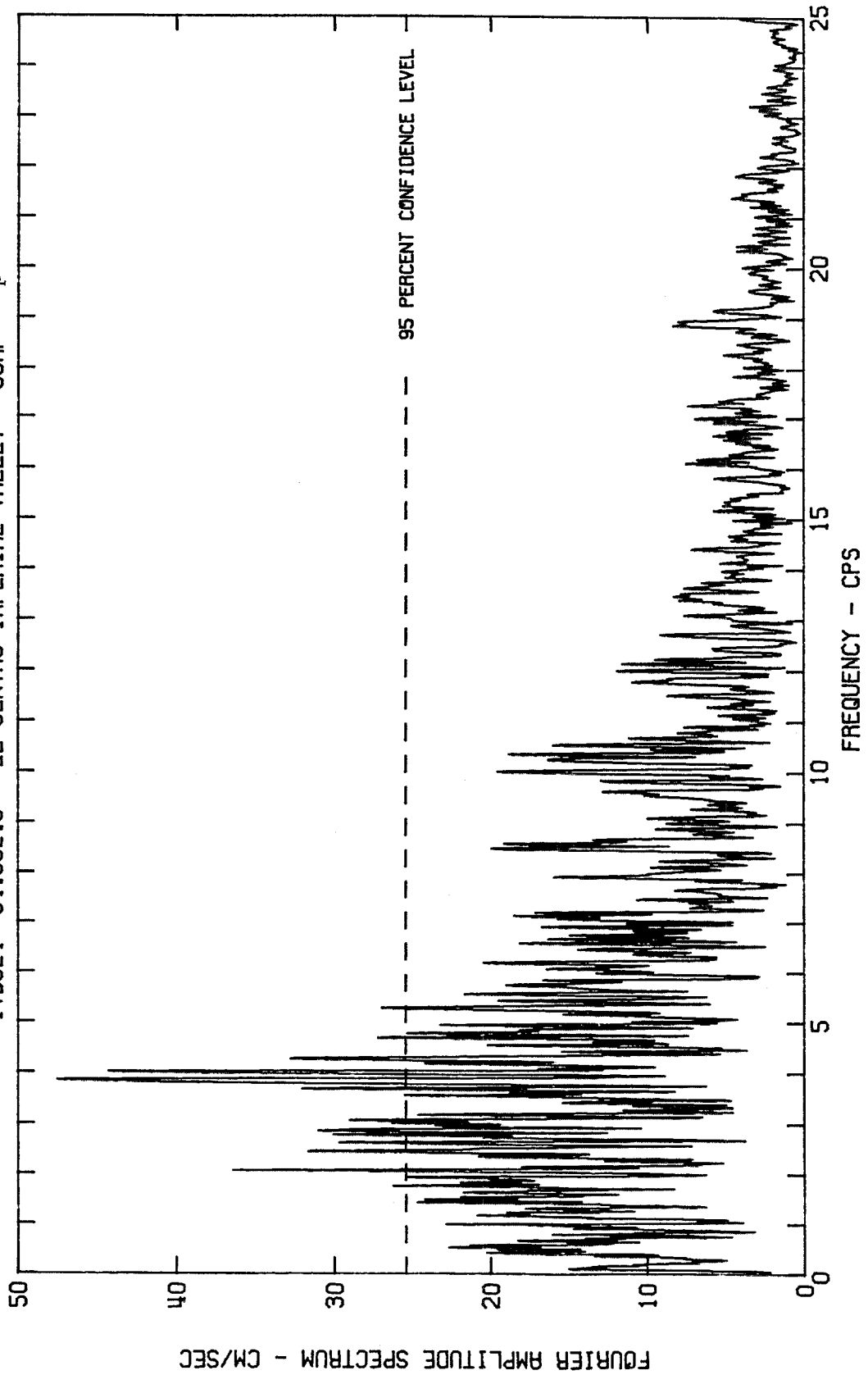
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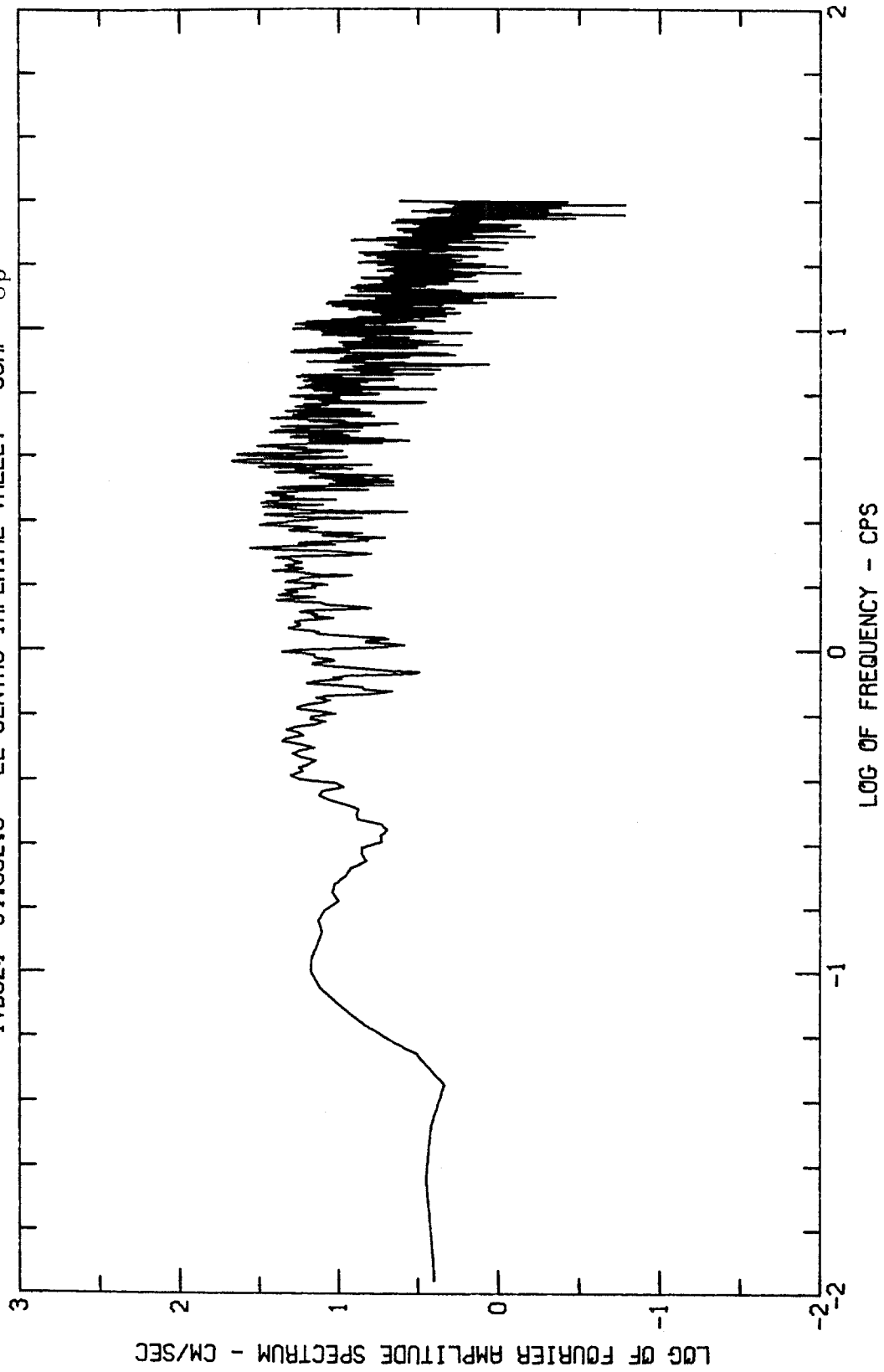
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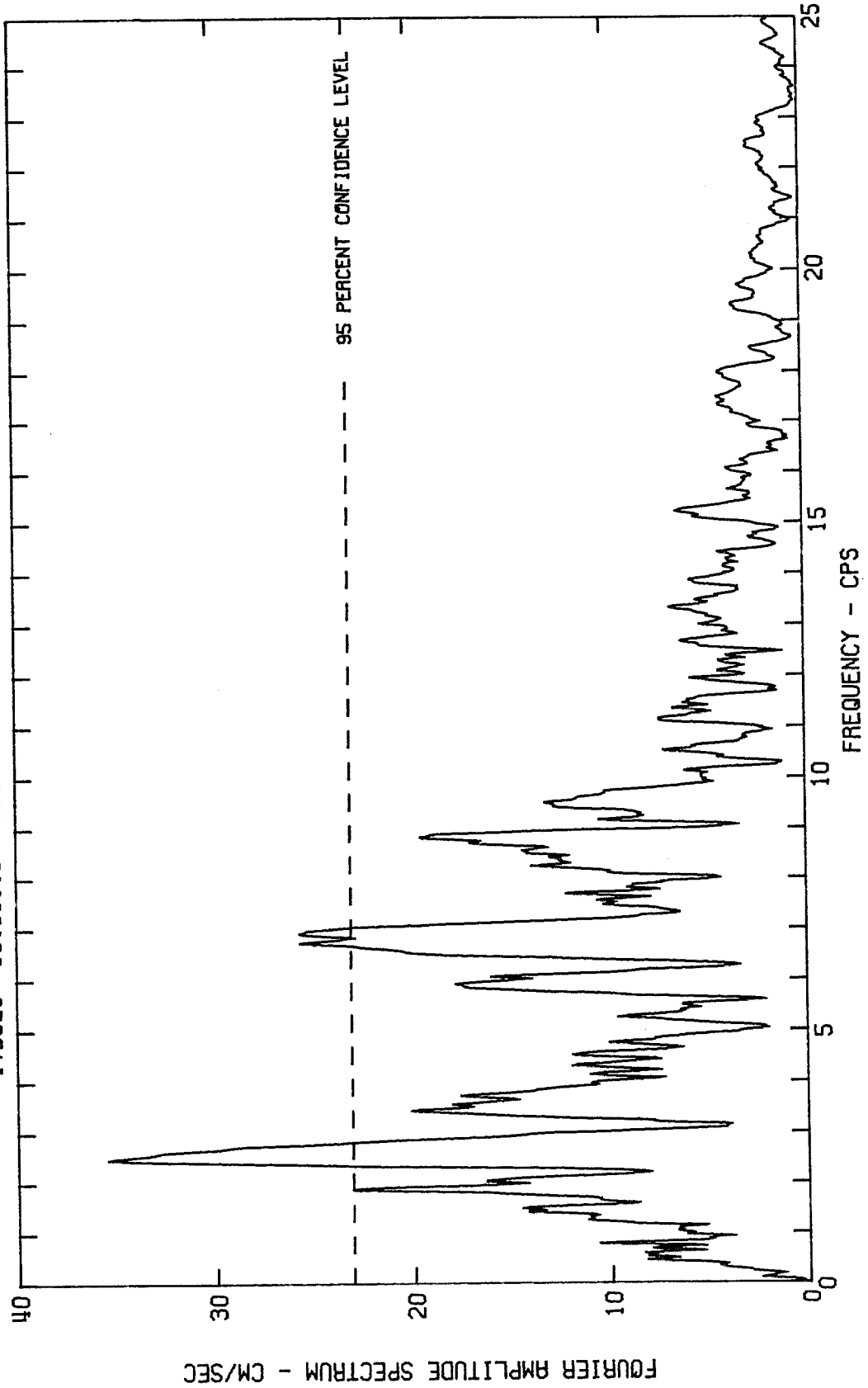
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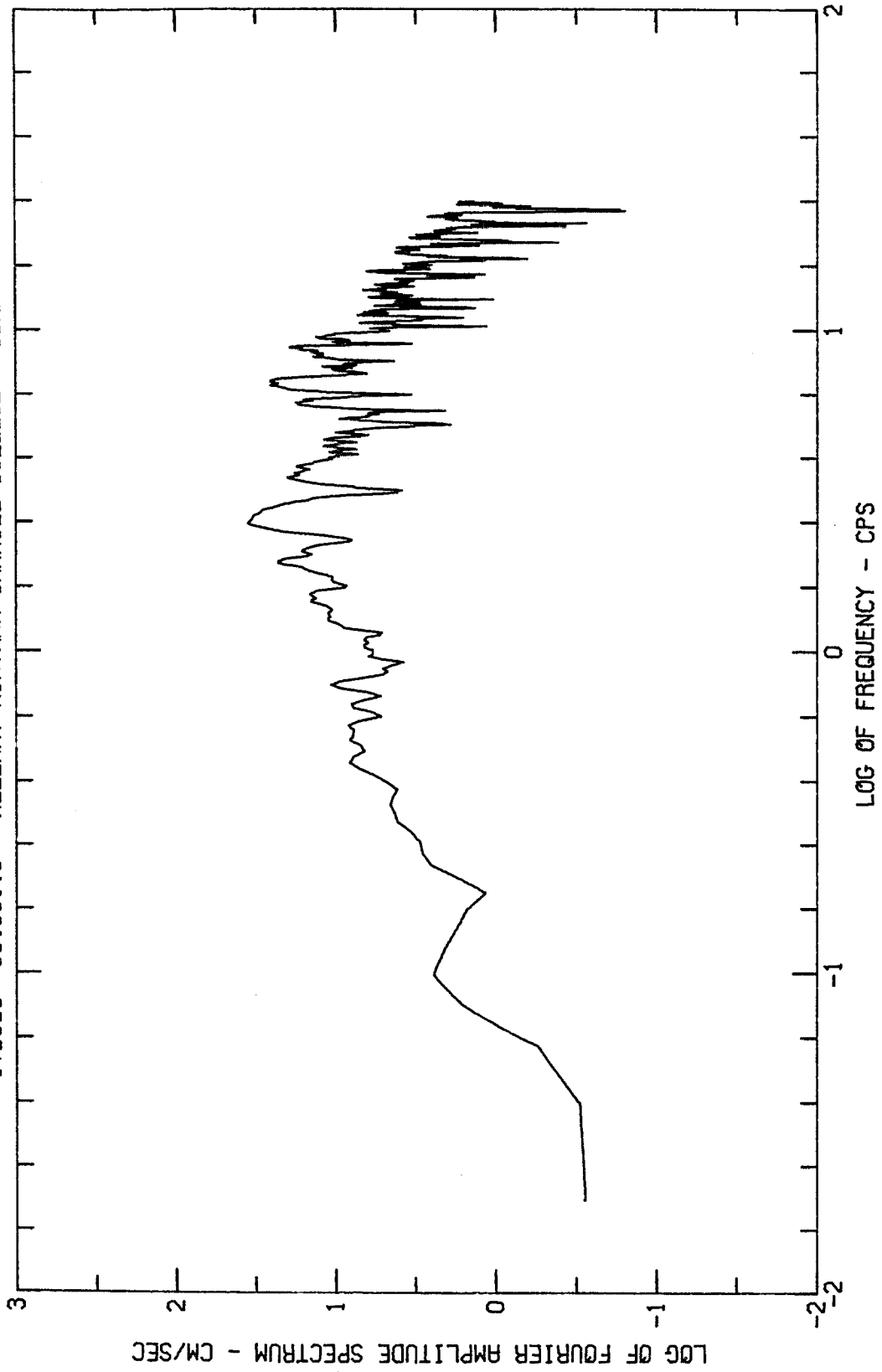
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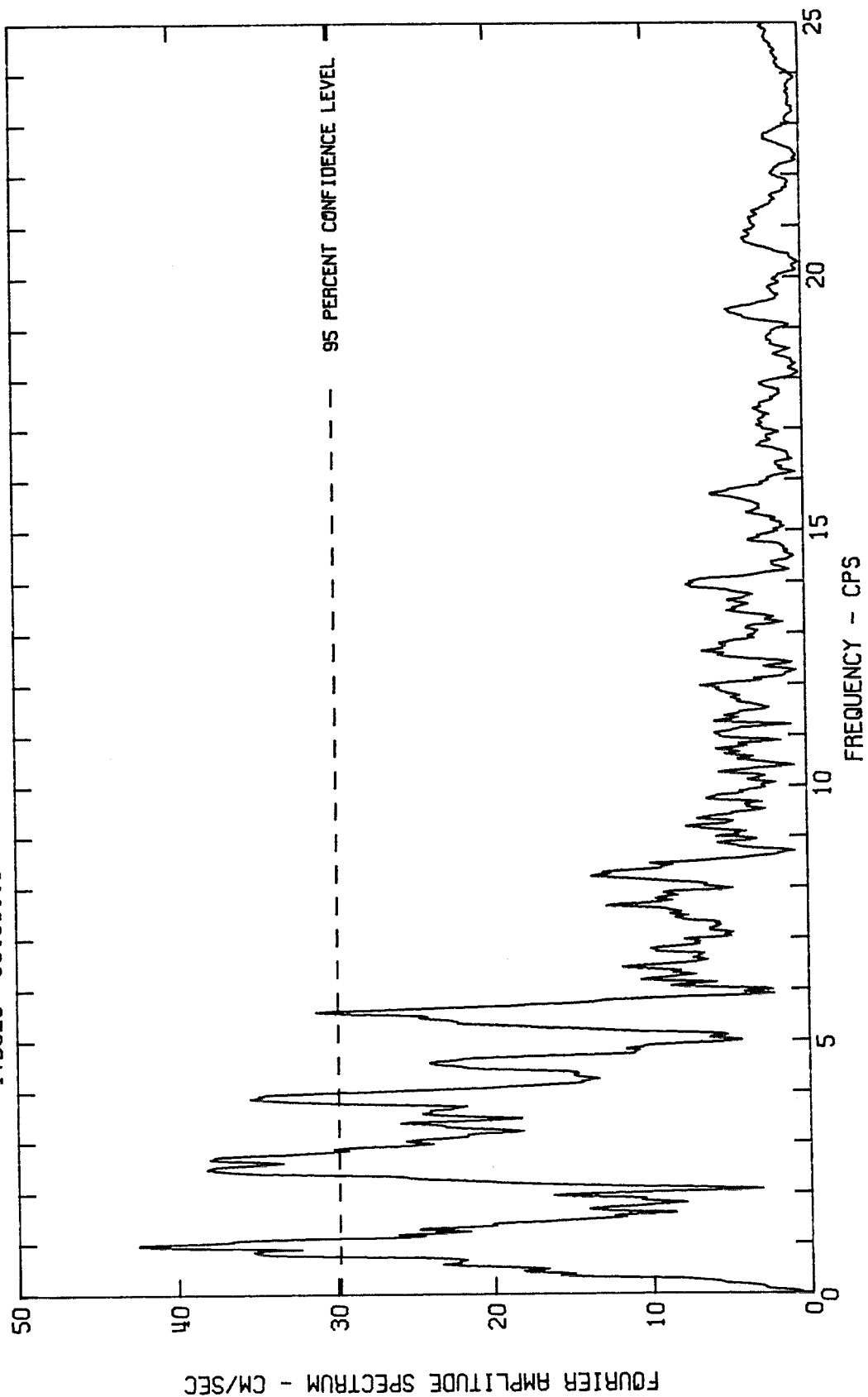
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
HELENA, MONTANA EARTHQUAKE OCT 31, 1935 - 1138 MST
IV8025 35.001.0 HELENA, MONTANA CARROLL COLLEGE COMP N00E



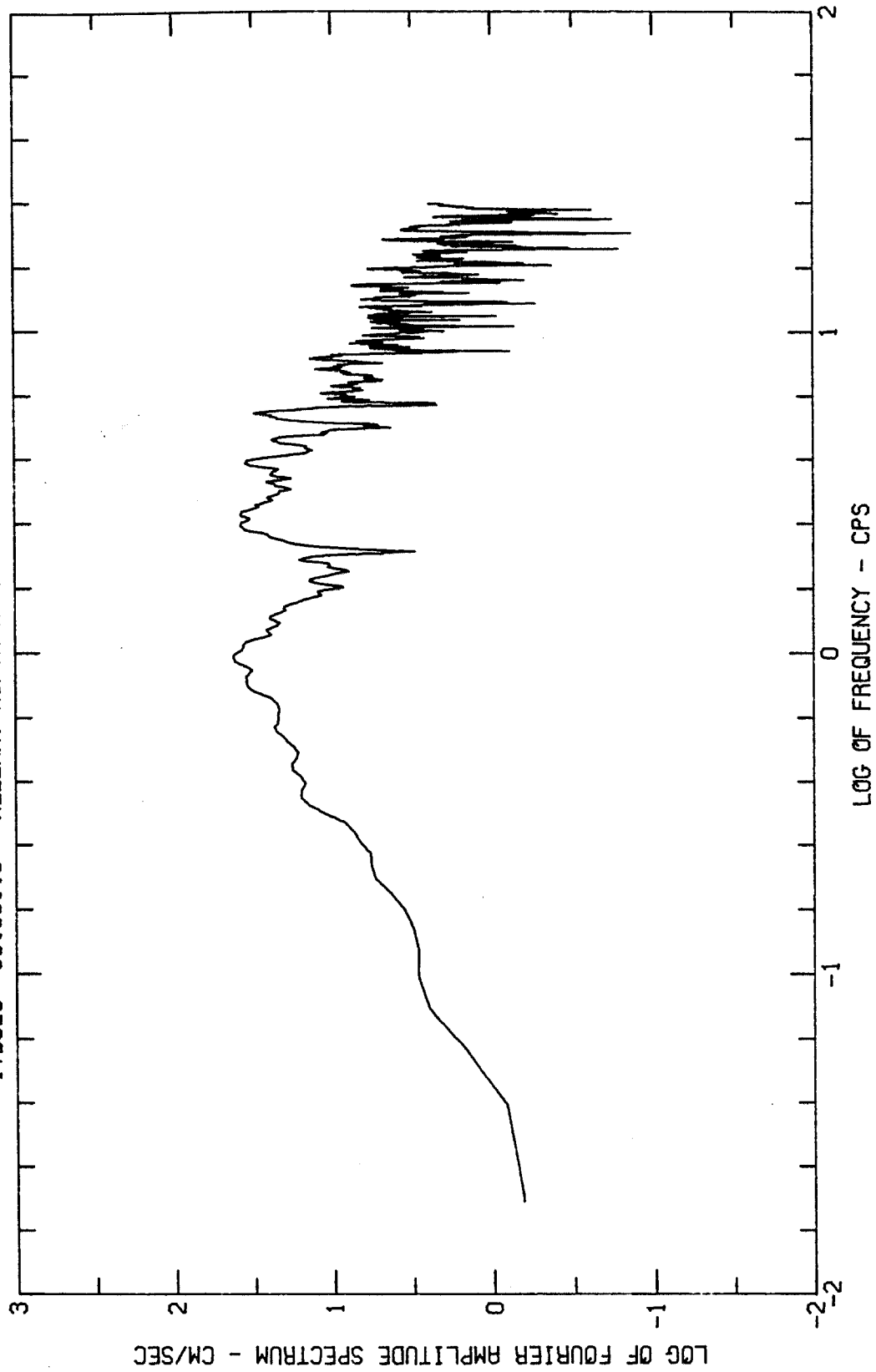
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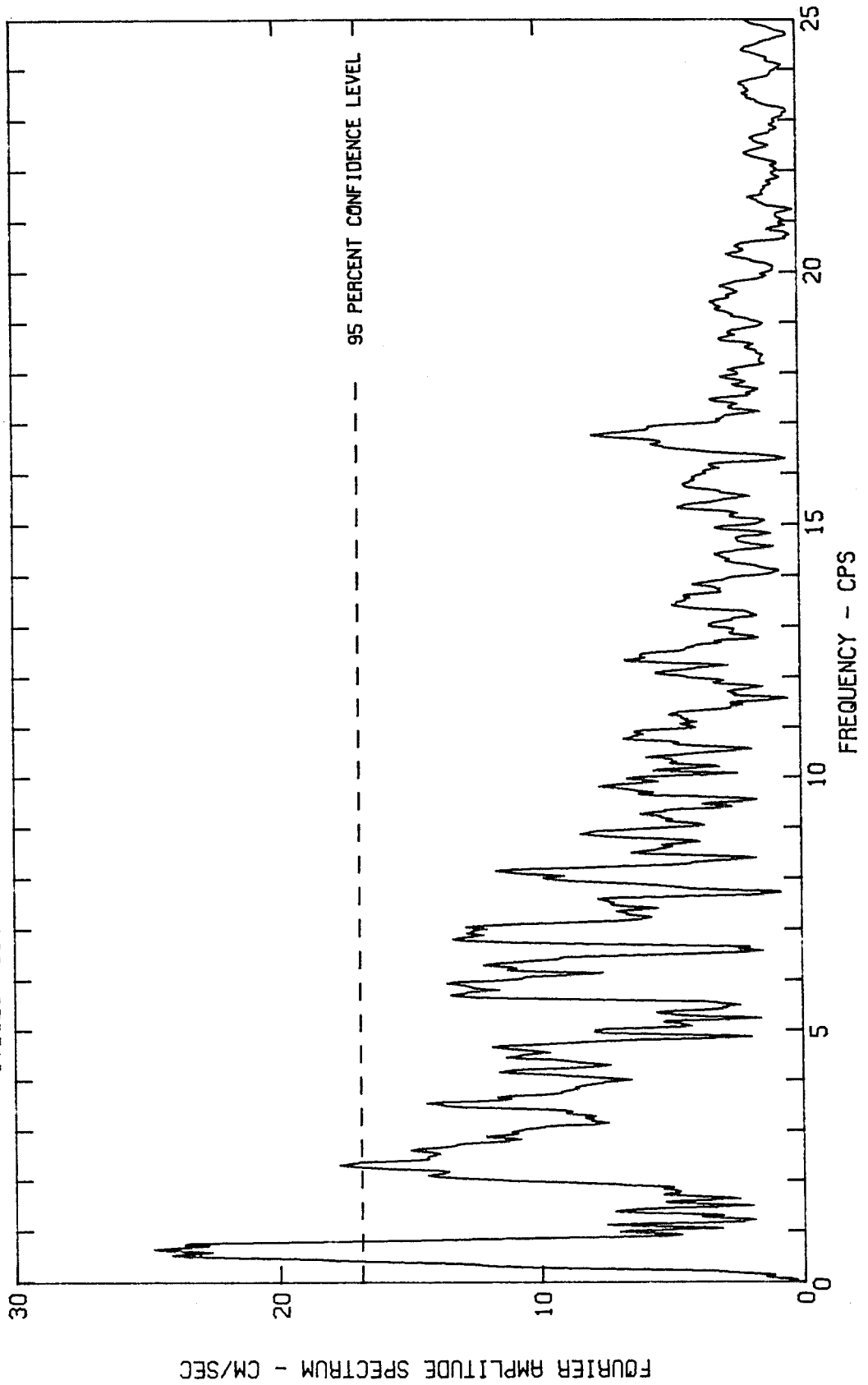
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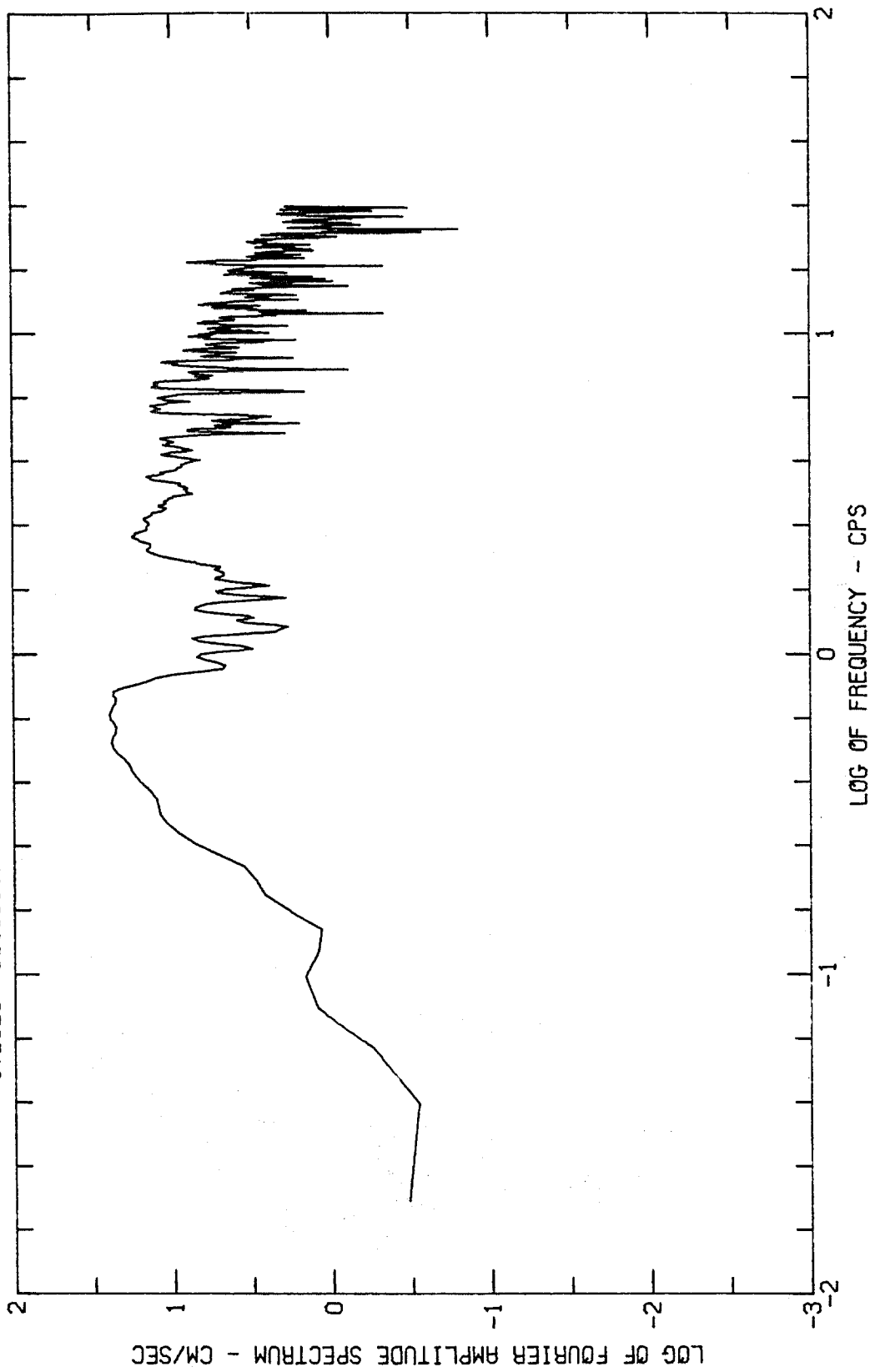
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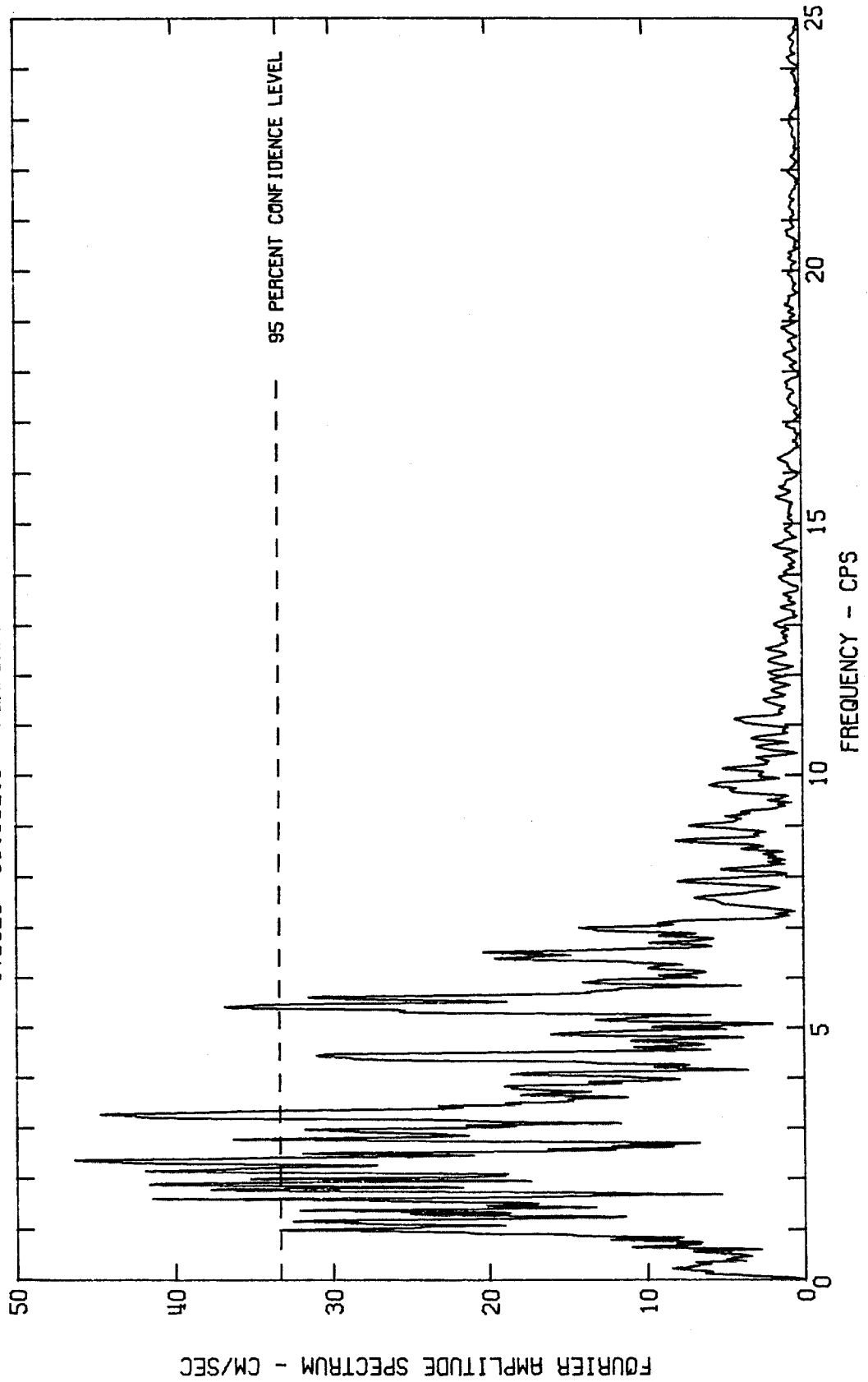
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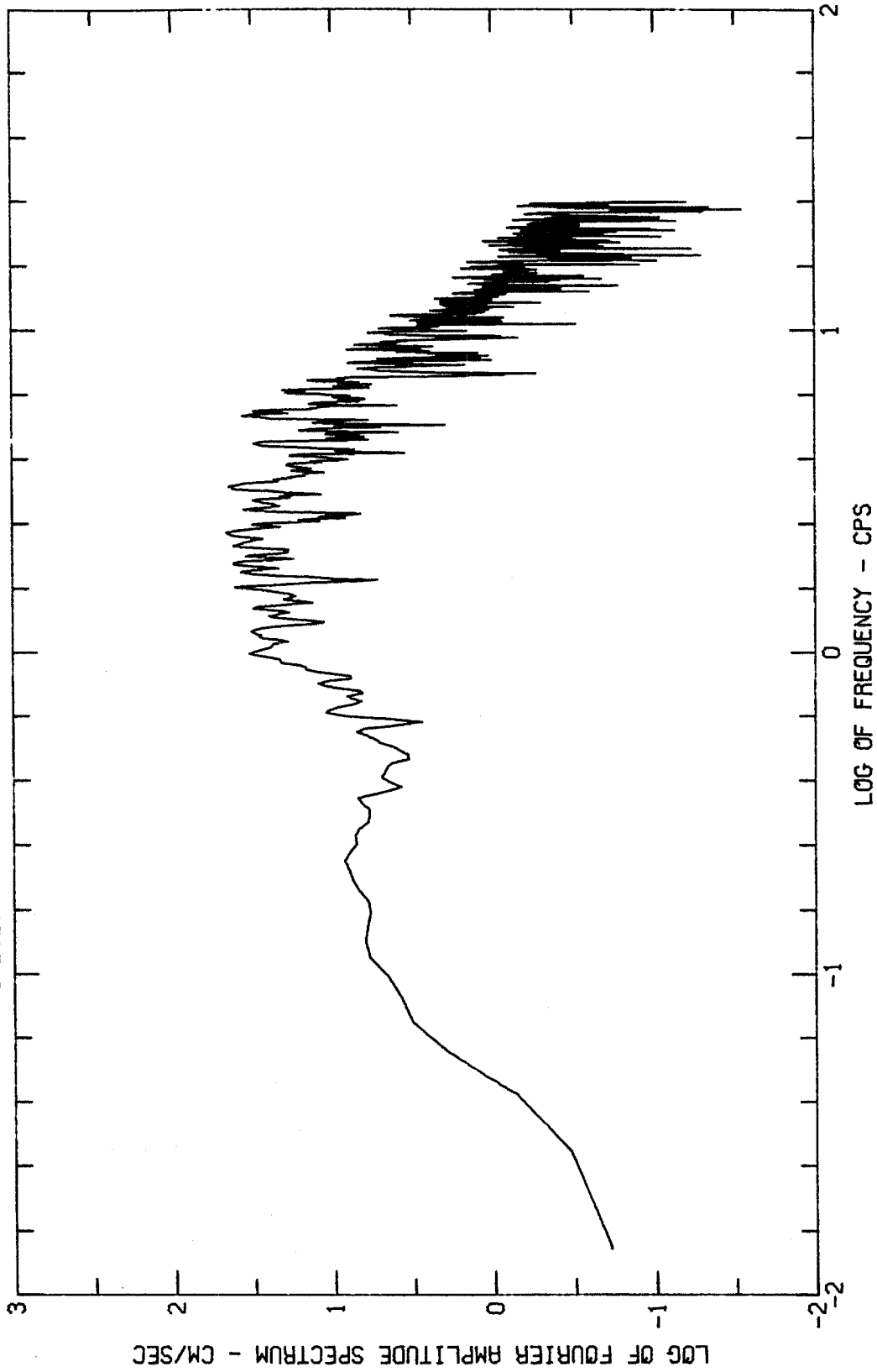
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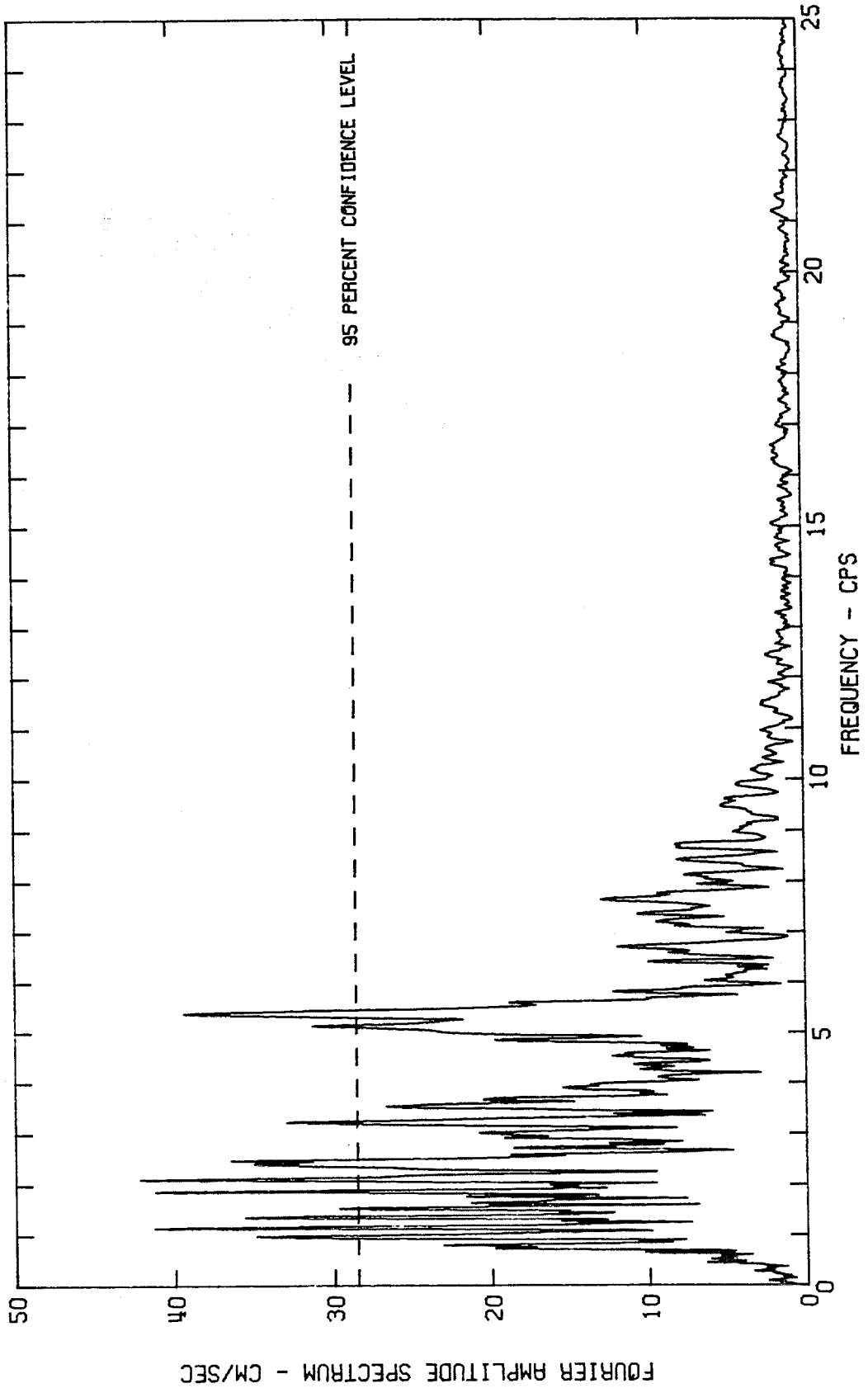
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
1ST NORTHWEST CALIFORNIA EARTHQUAKE SEPT 11, 1938 - 2210 PST
1VB026 38.002.0 FERNDALE CITY HALL COMP S45W



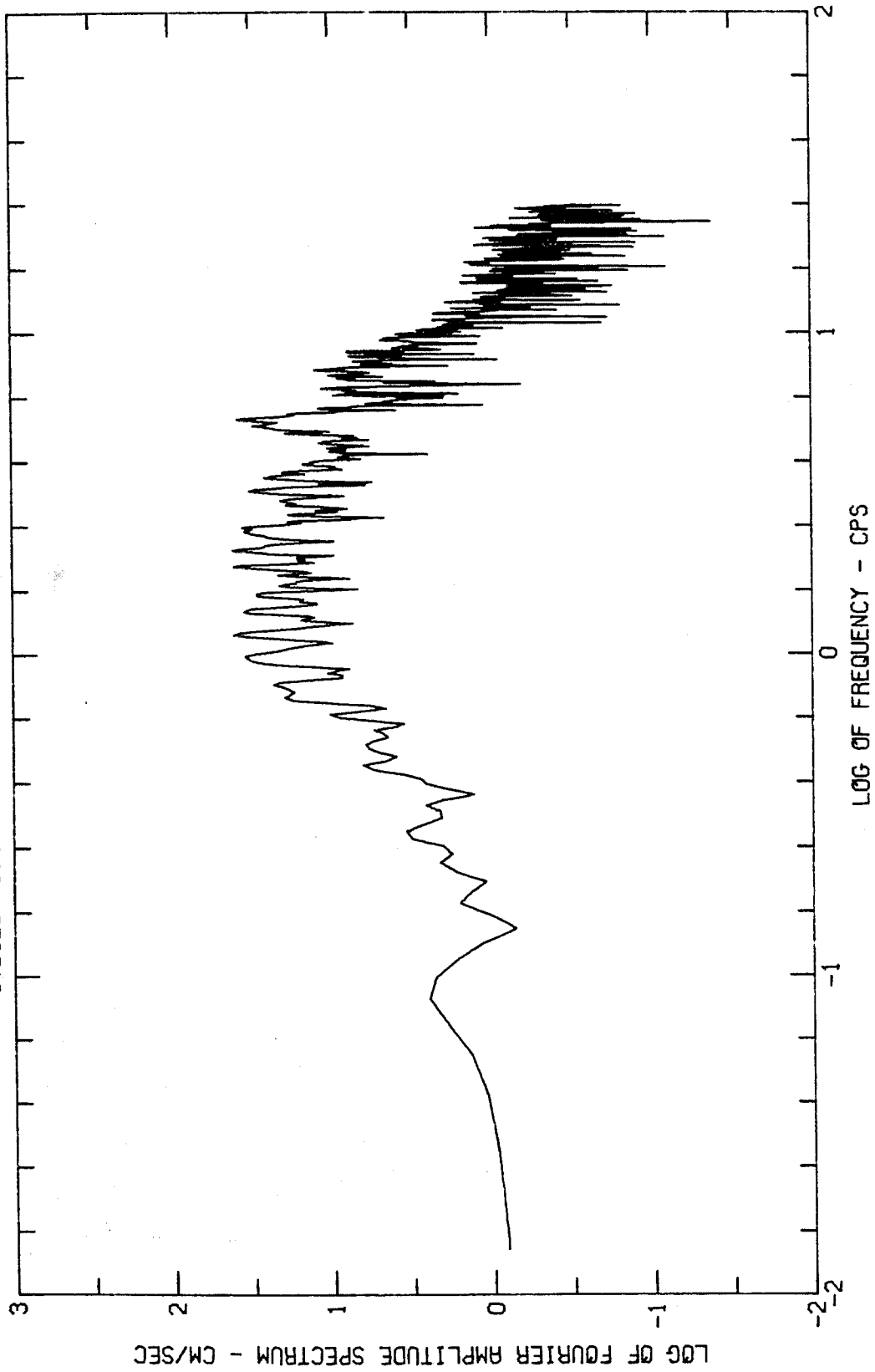
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
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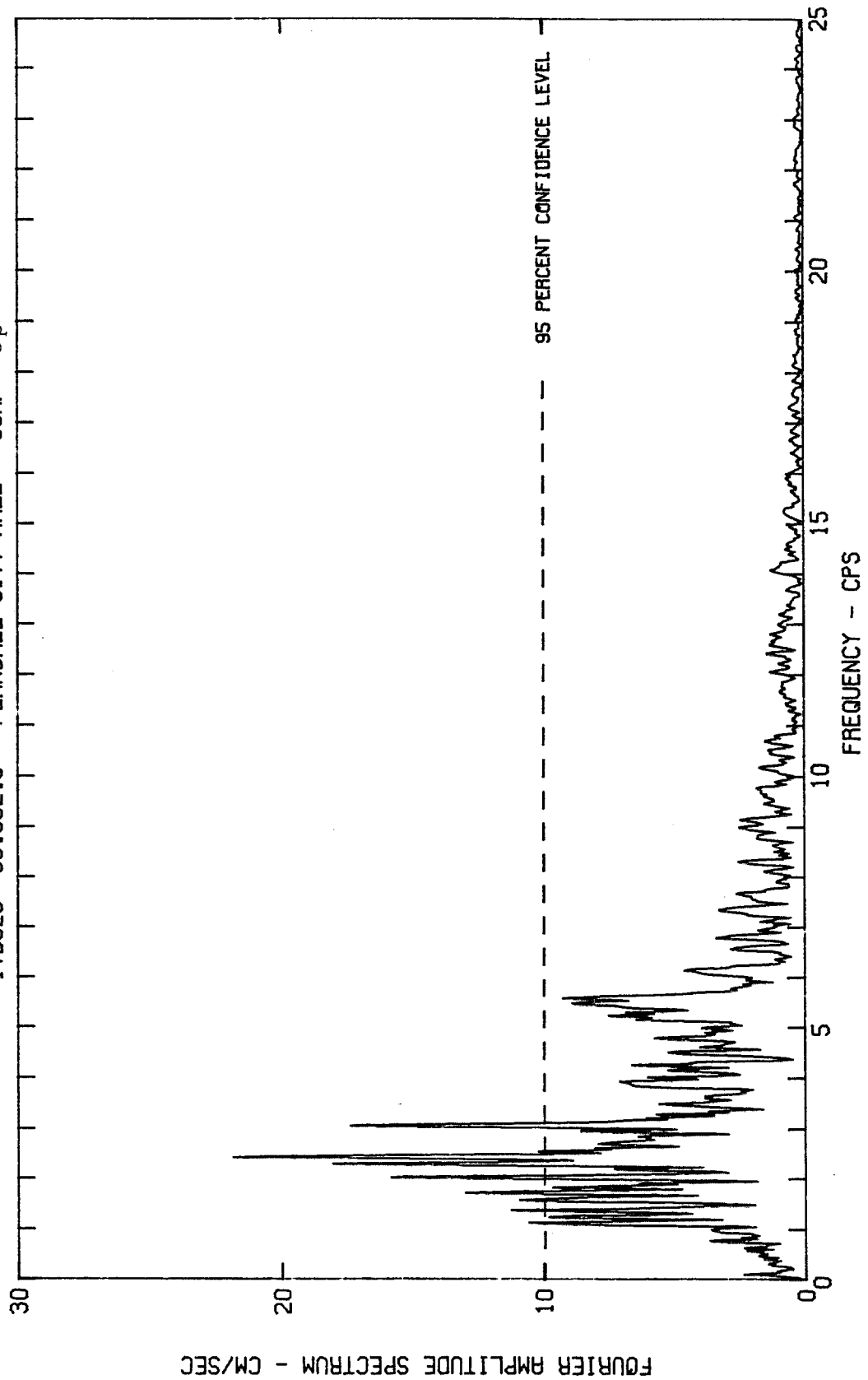
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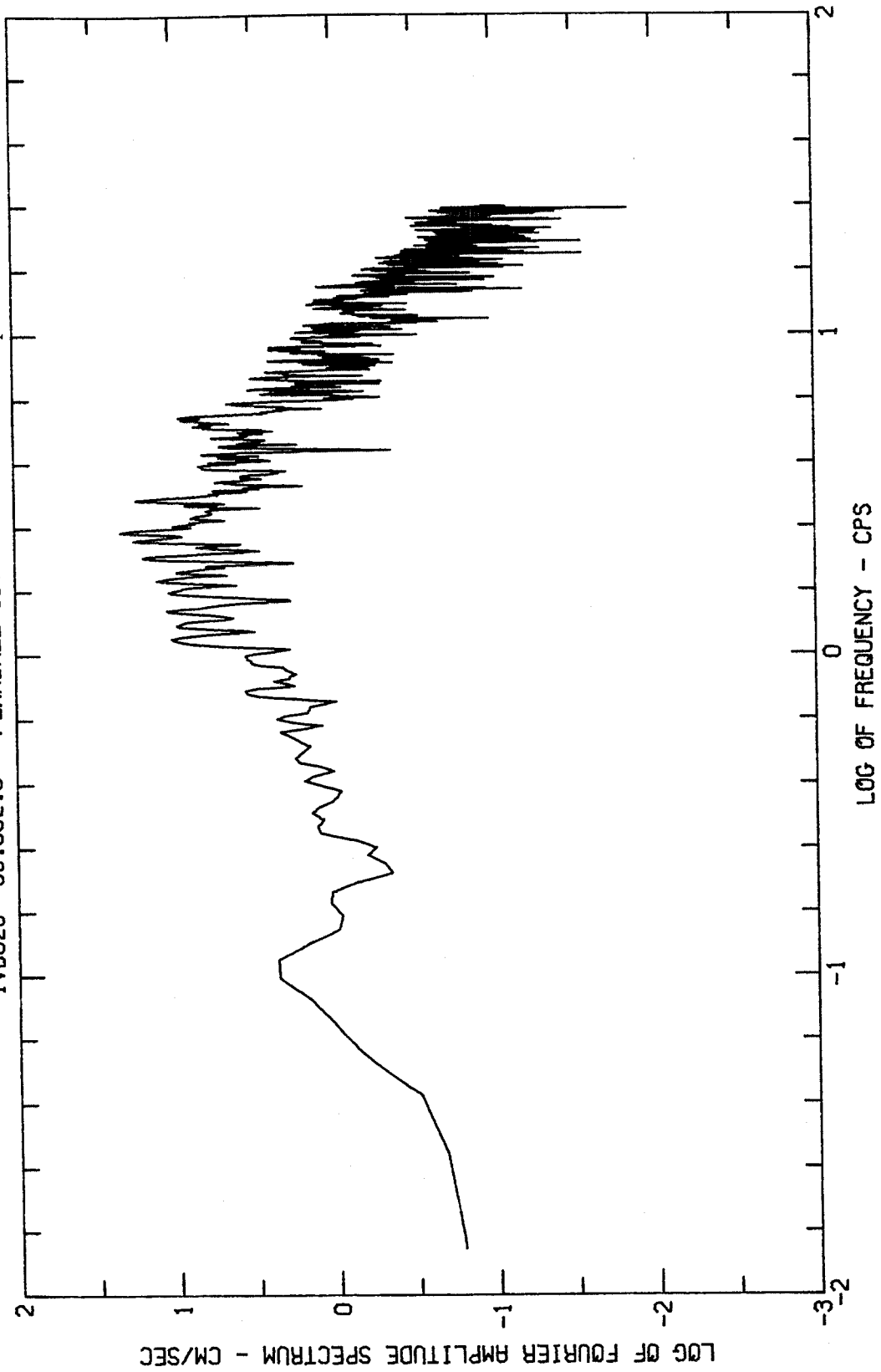
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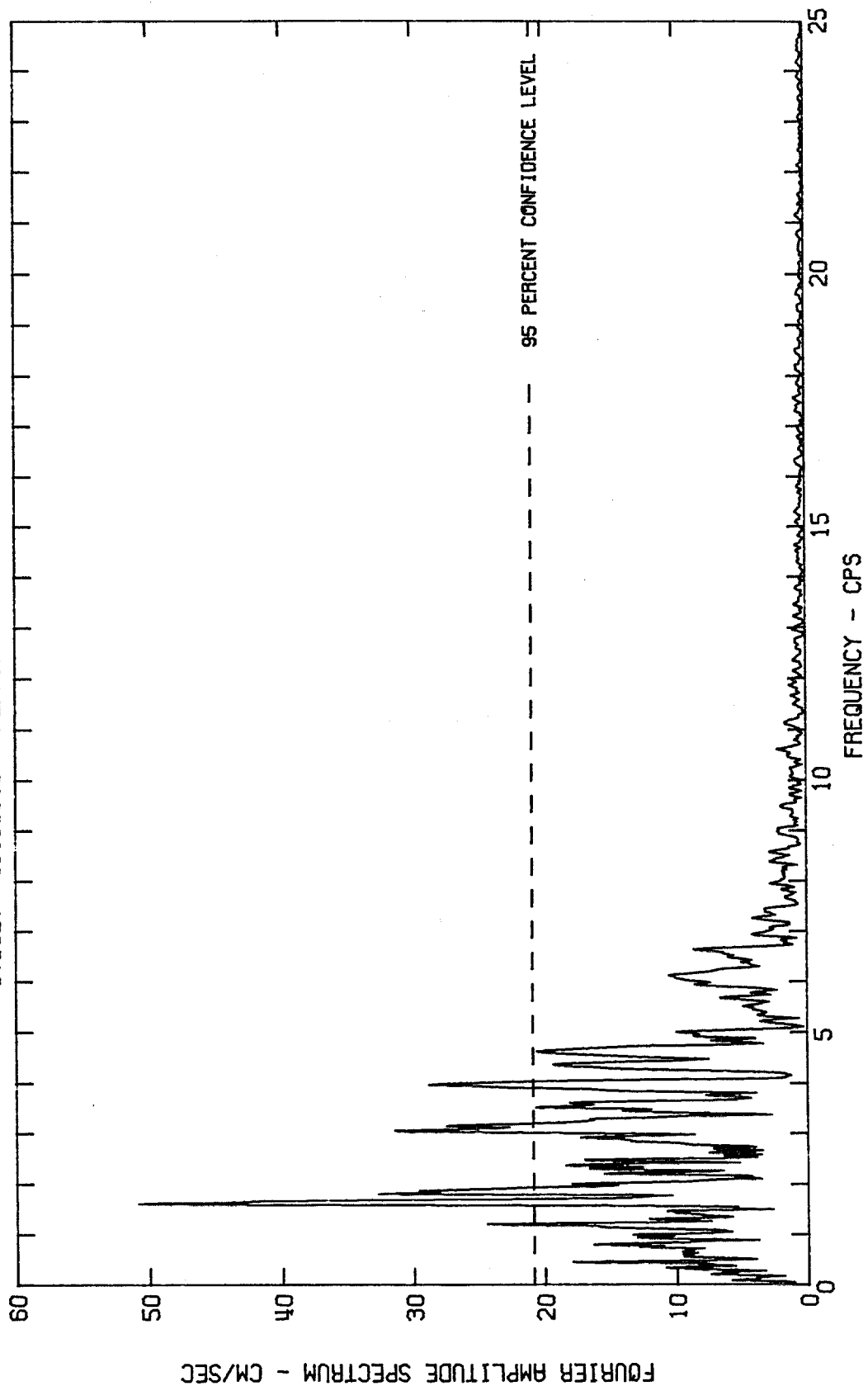
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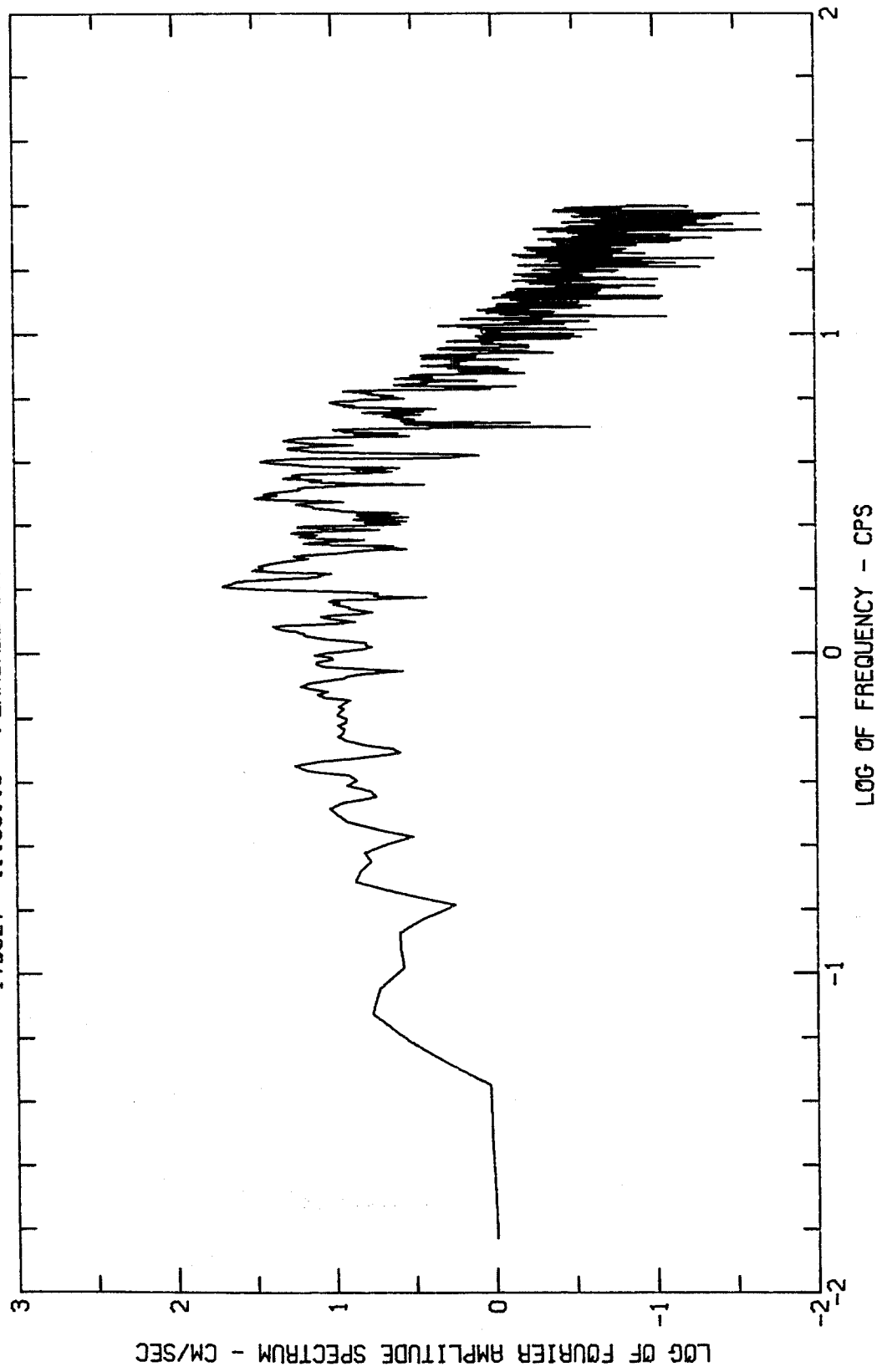
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IVB026 38.002.0 FERNDALE CITY HALL COMP Up



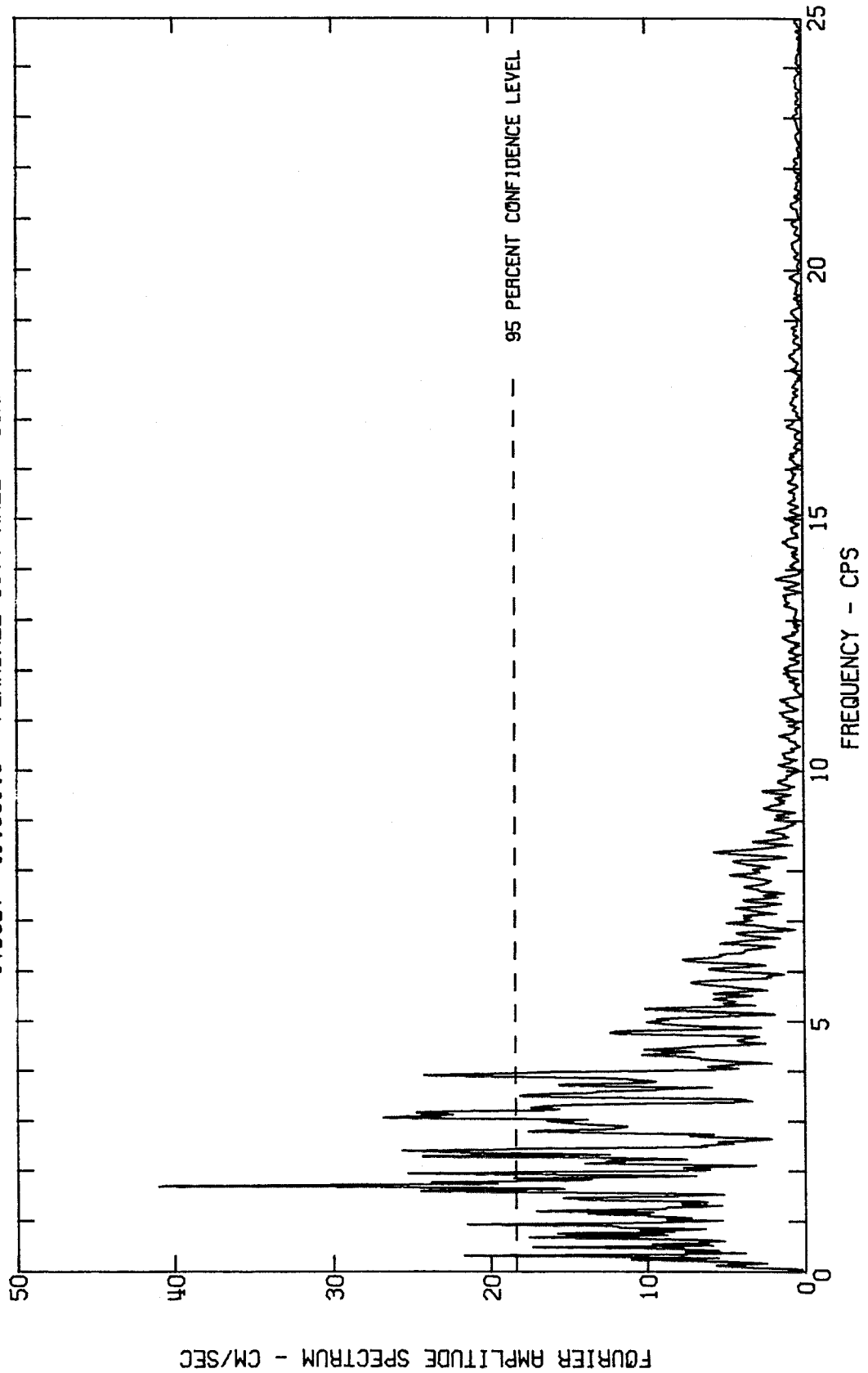
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
2ND NORTHWEST CALIFORNIA EARTHQUAKE FEB 9, 1941 - 0145 PST
1VB027 41.001.0 FERNDAL CITY HALL COMP S45W



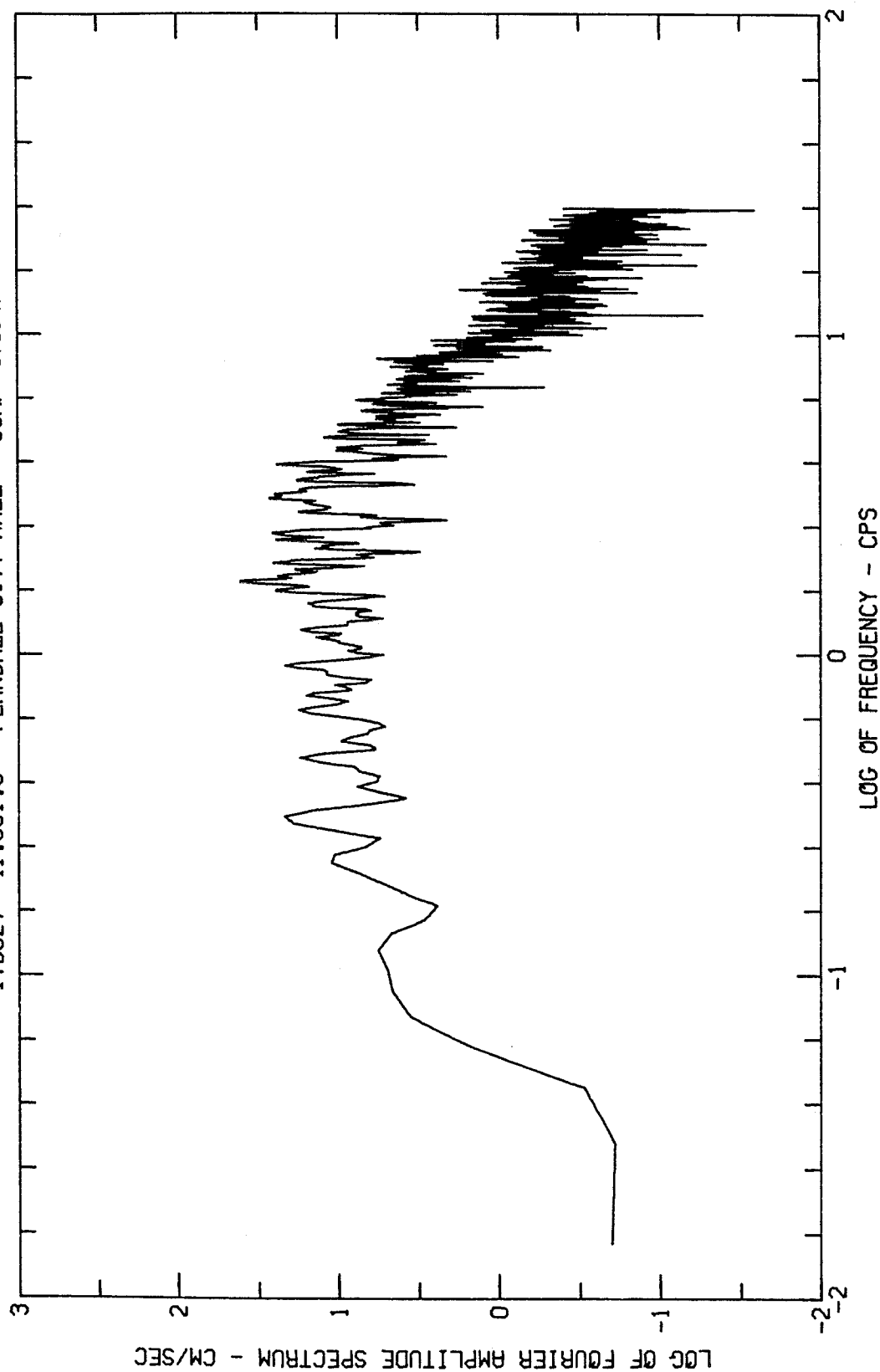
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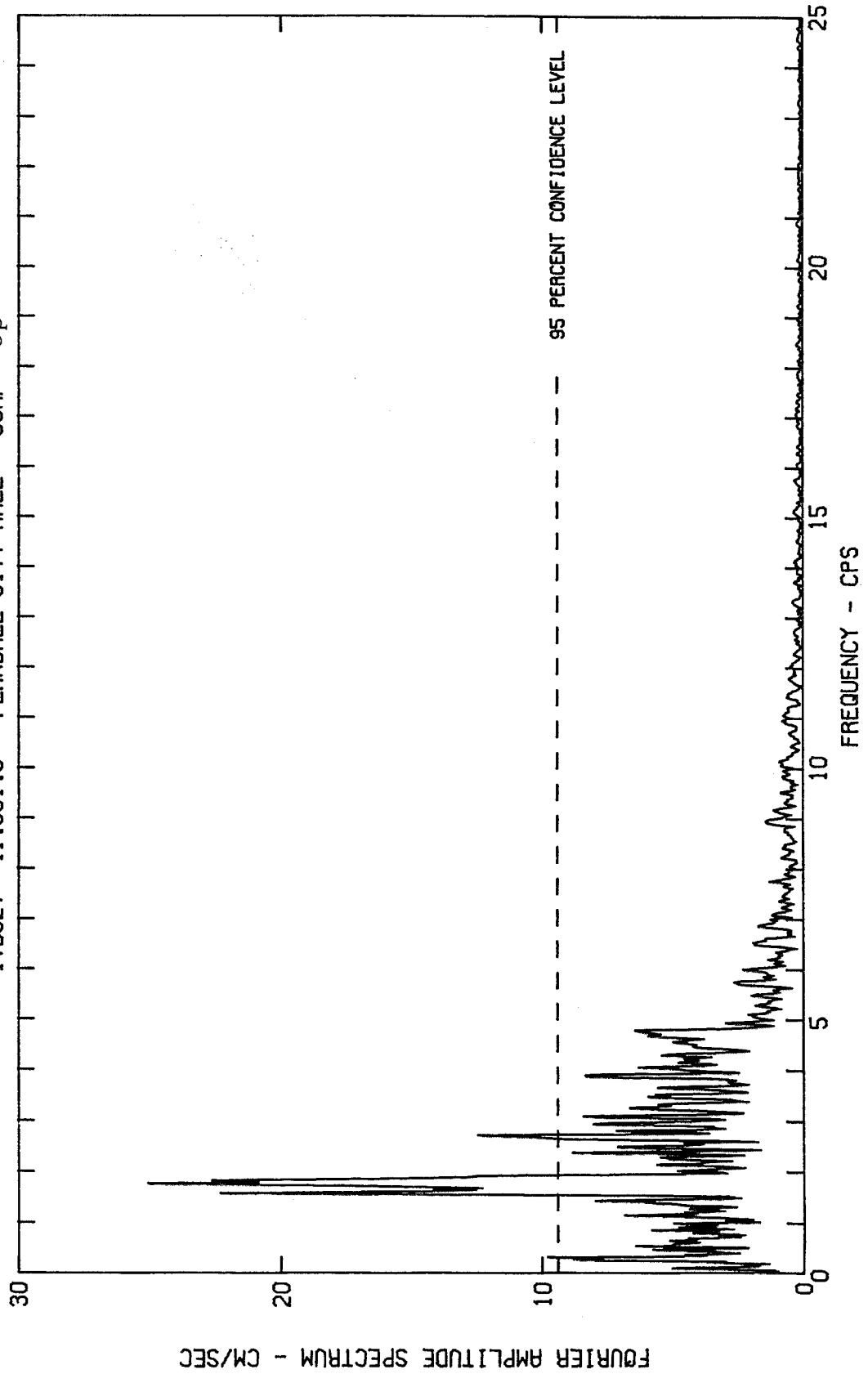
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
2ND NORTHWEST CALIFORNIA EARTHQUAKE FEB 9, 1941 - 0145 PST
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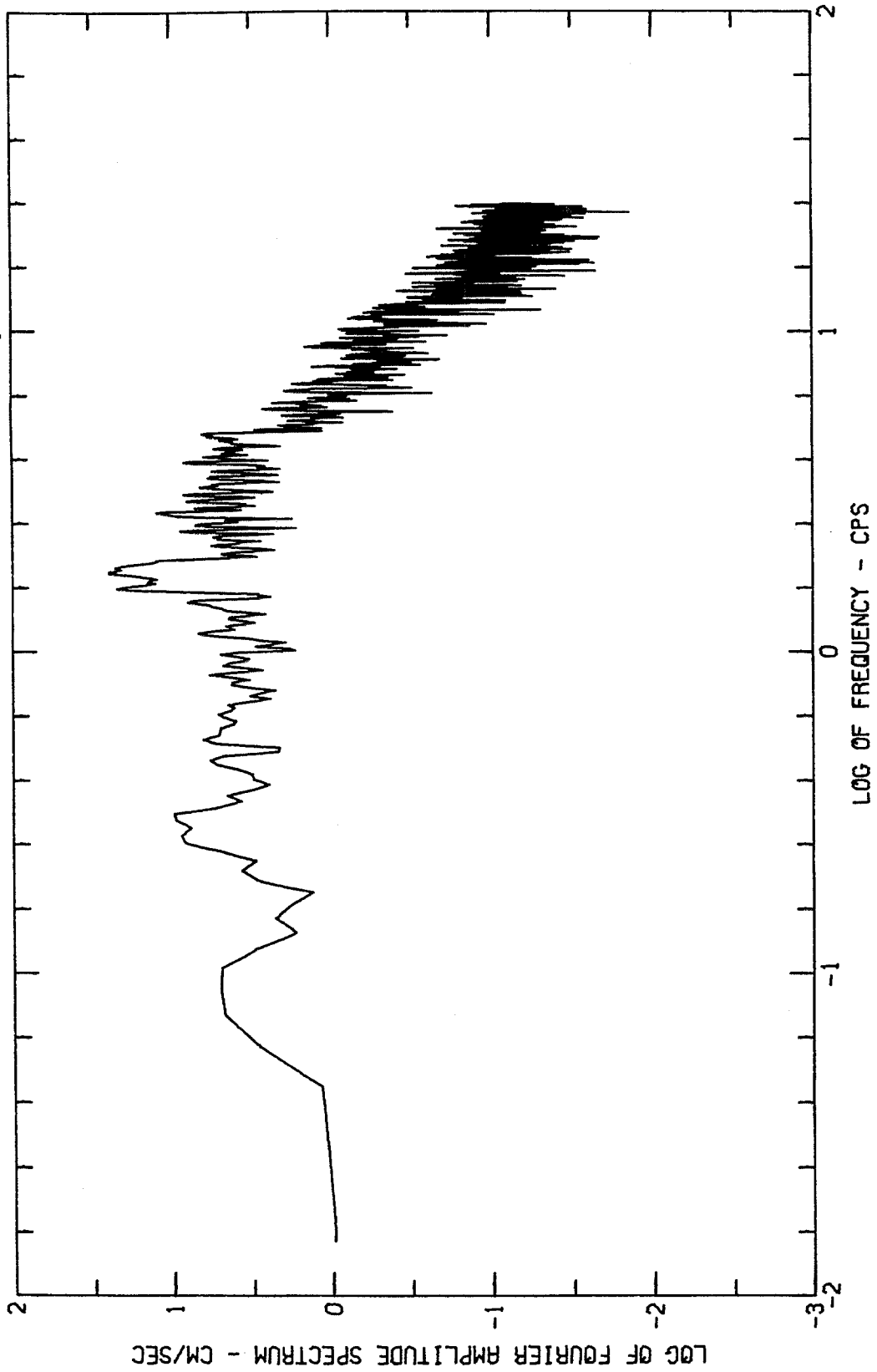
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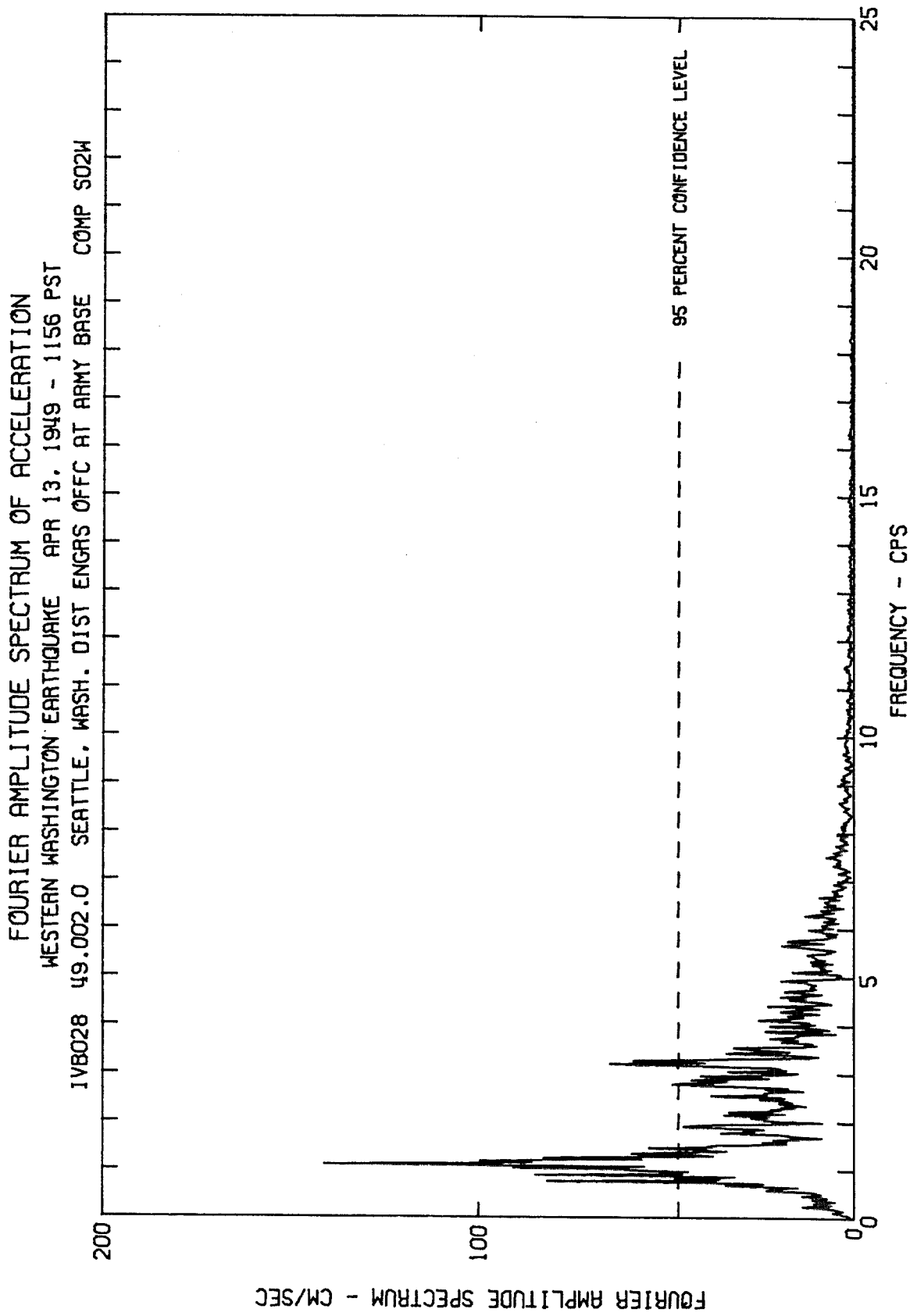


FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
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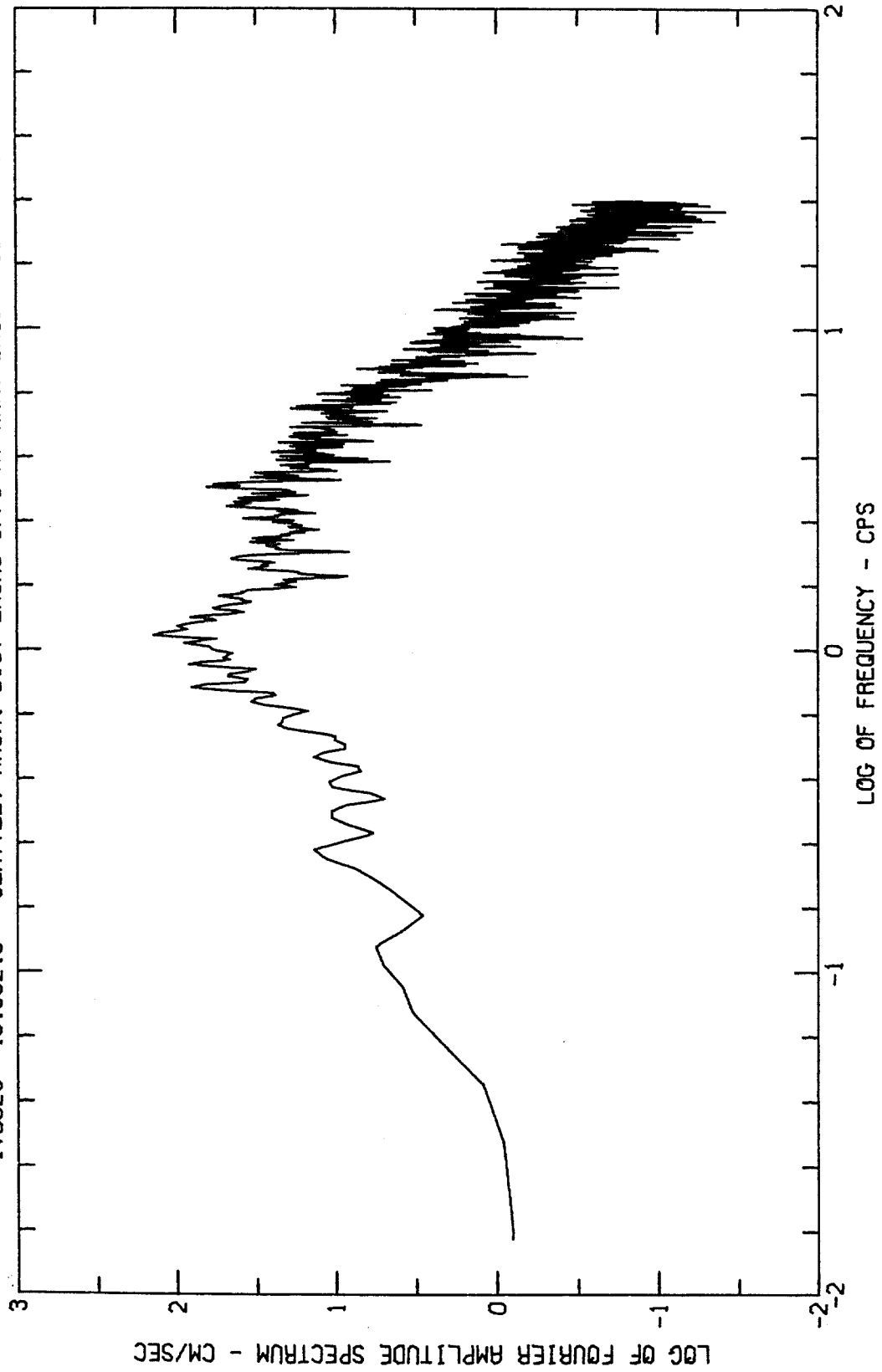


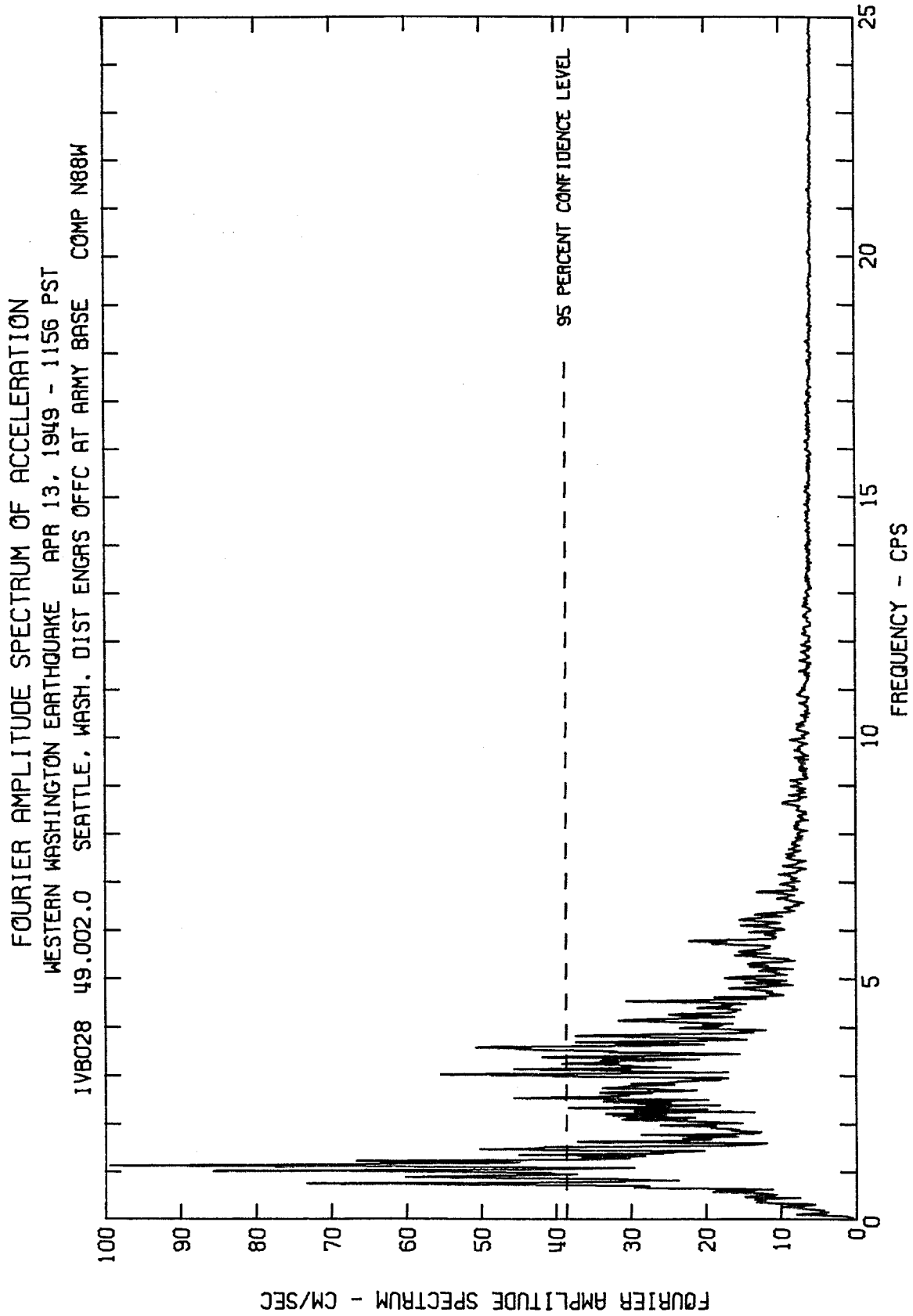
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
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1V8027 41.001.0 FERNDALE CITY HALL COMP Up



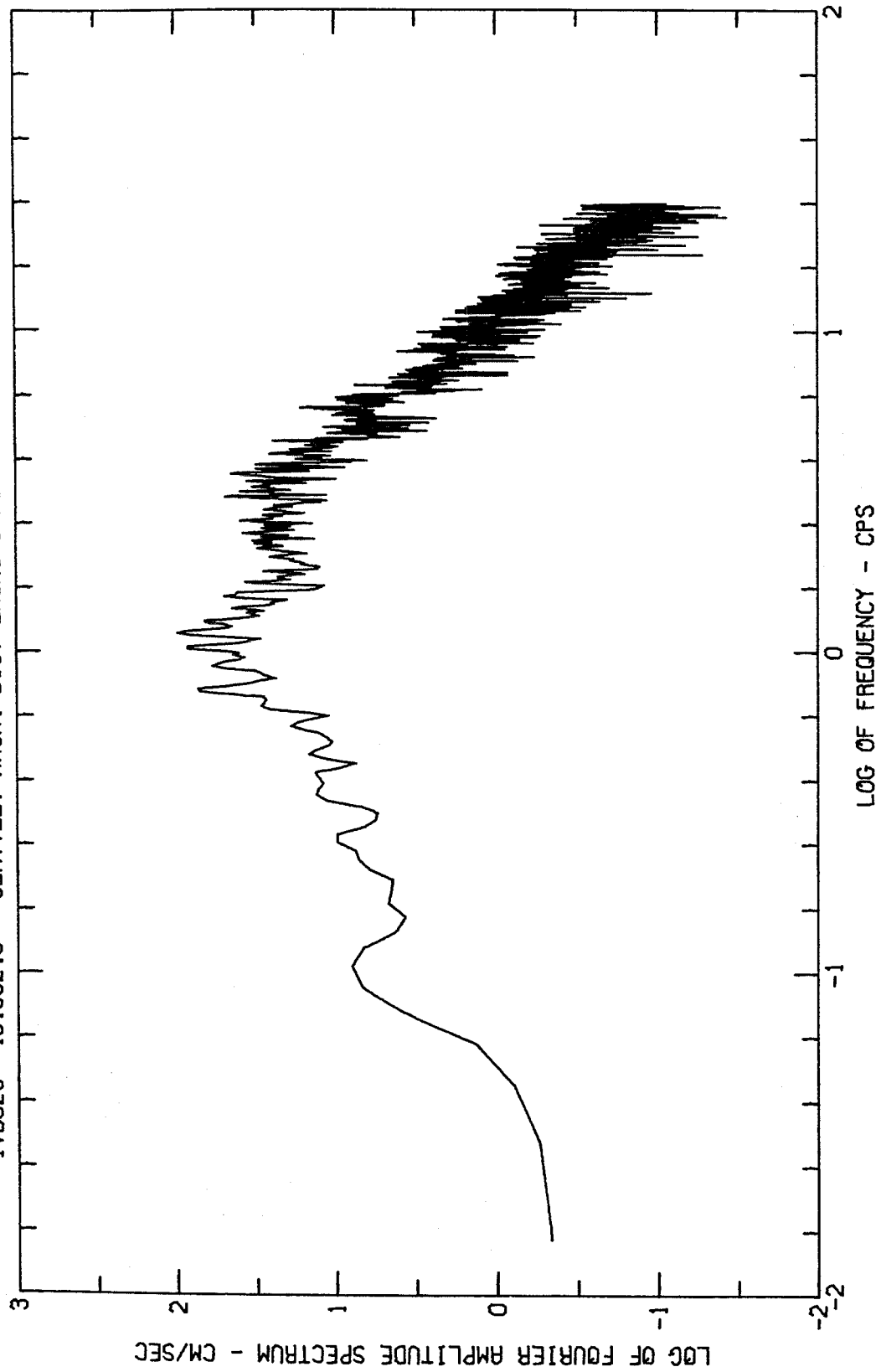


FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
WESTERN WASHINGTON EARTHQUAKE APR 13, 1949 - 1156 PST
1VB028 49.002.0 SEATTLE, WASH. DIST ENGRS OFFC AT ARMY BASE COMP S02W

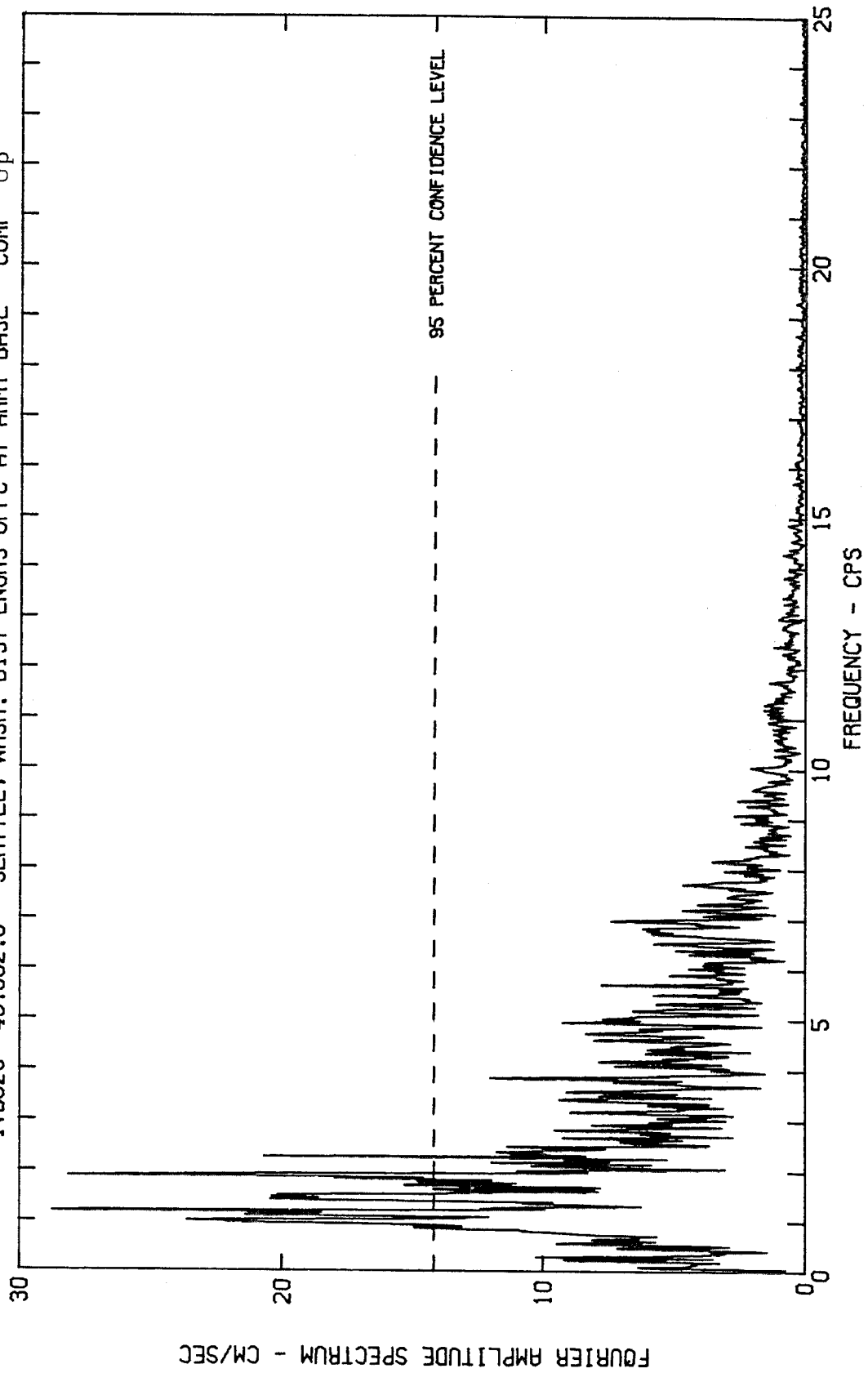




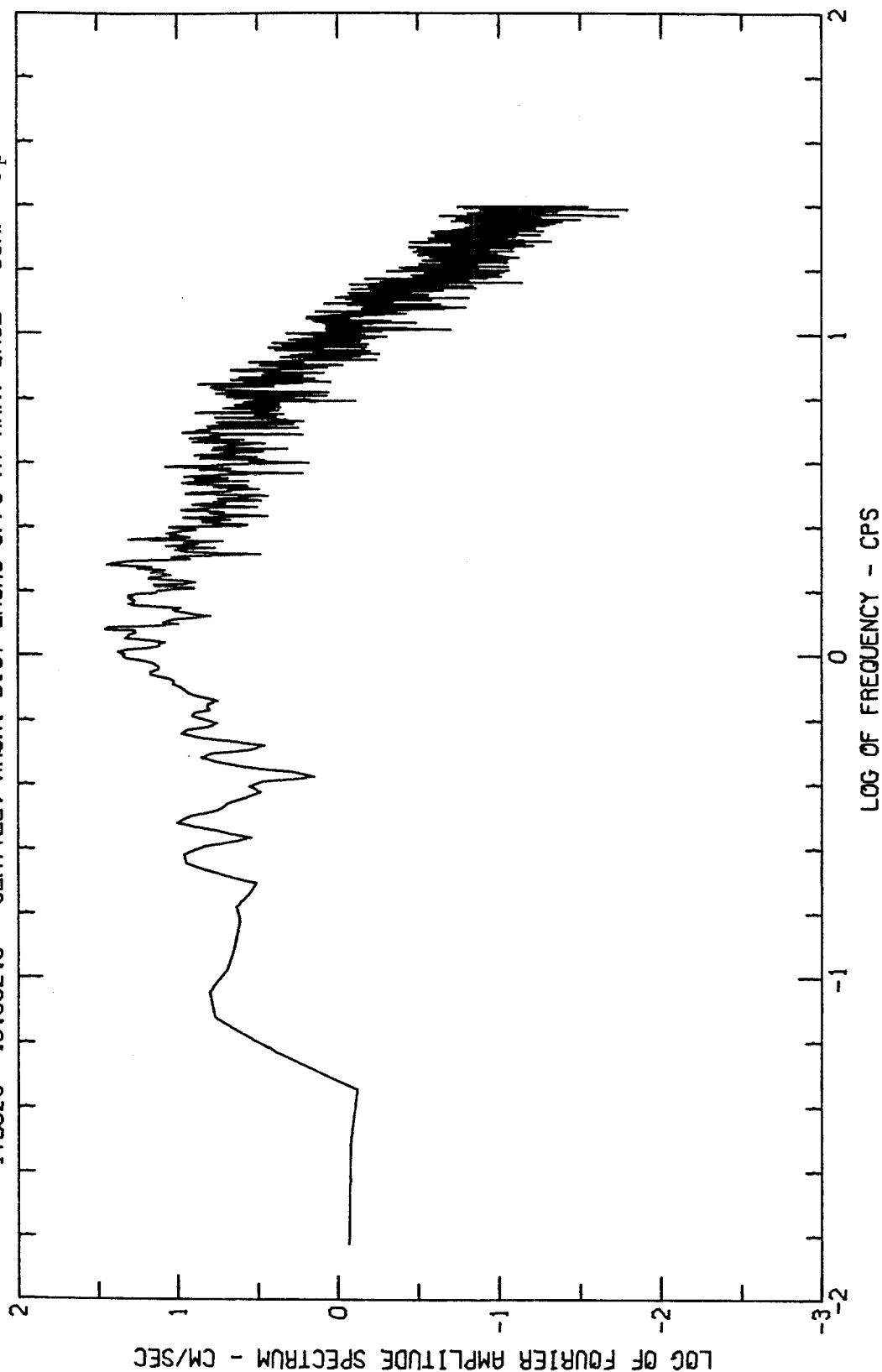
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
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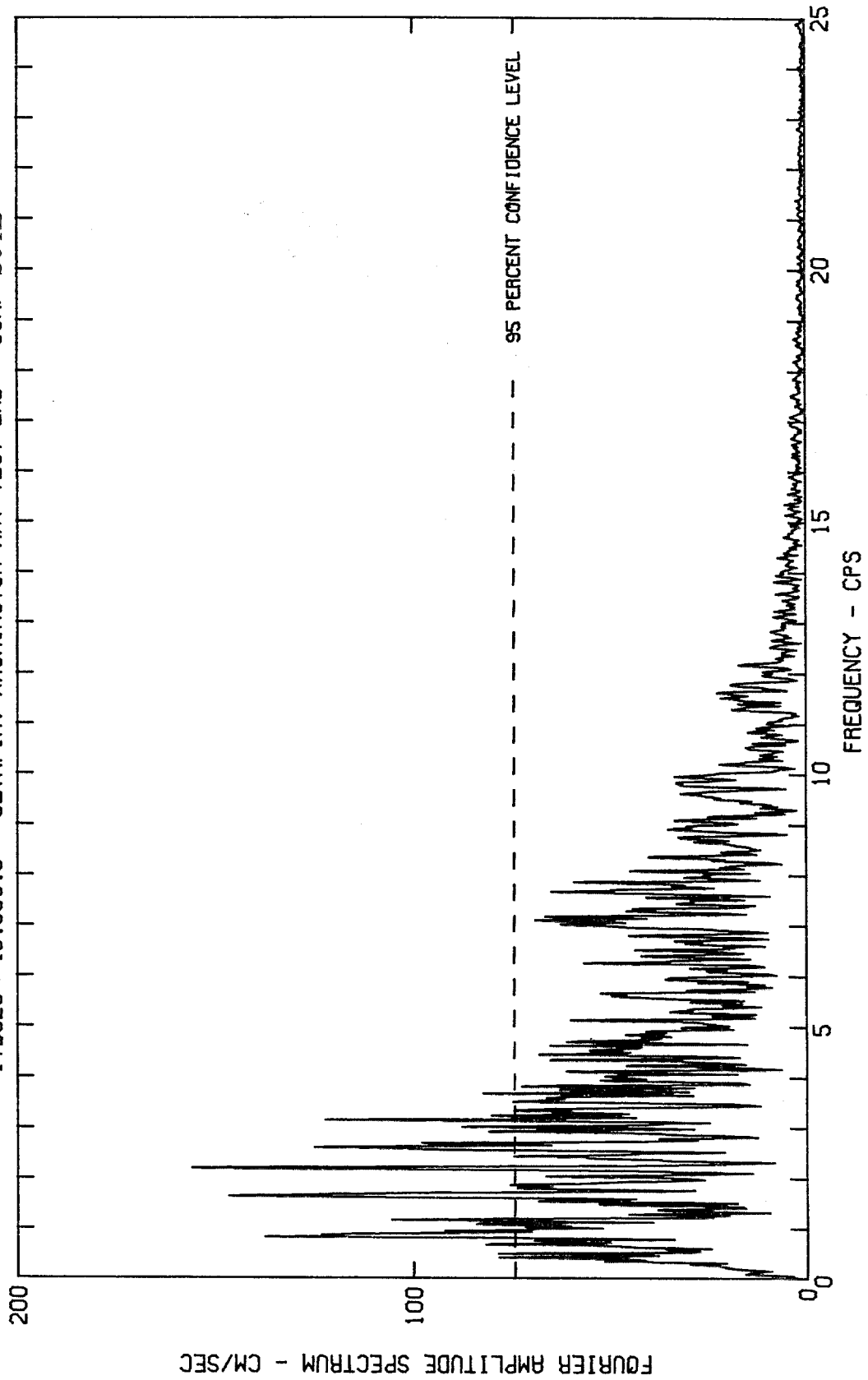
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
WESTERN WASHINGTON EARTHQUAKE APR 13, 1949 - 1156 PST
IV8028 49.002.0 SEATTLE, WASH. DIST ENGRS OFFC AT ARMY BASE COMP Up



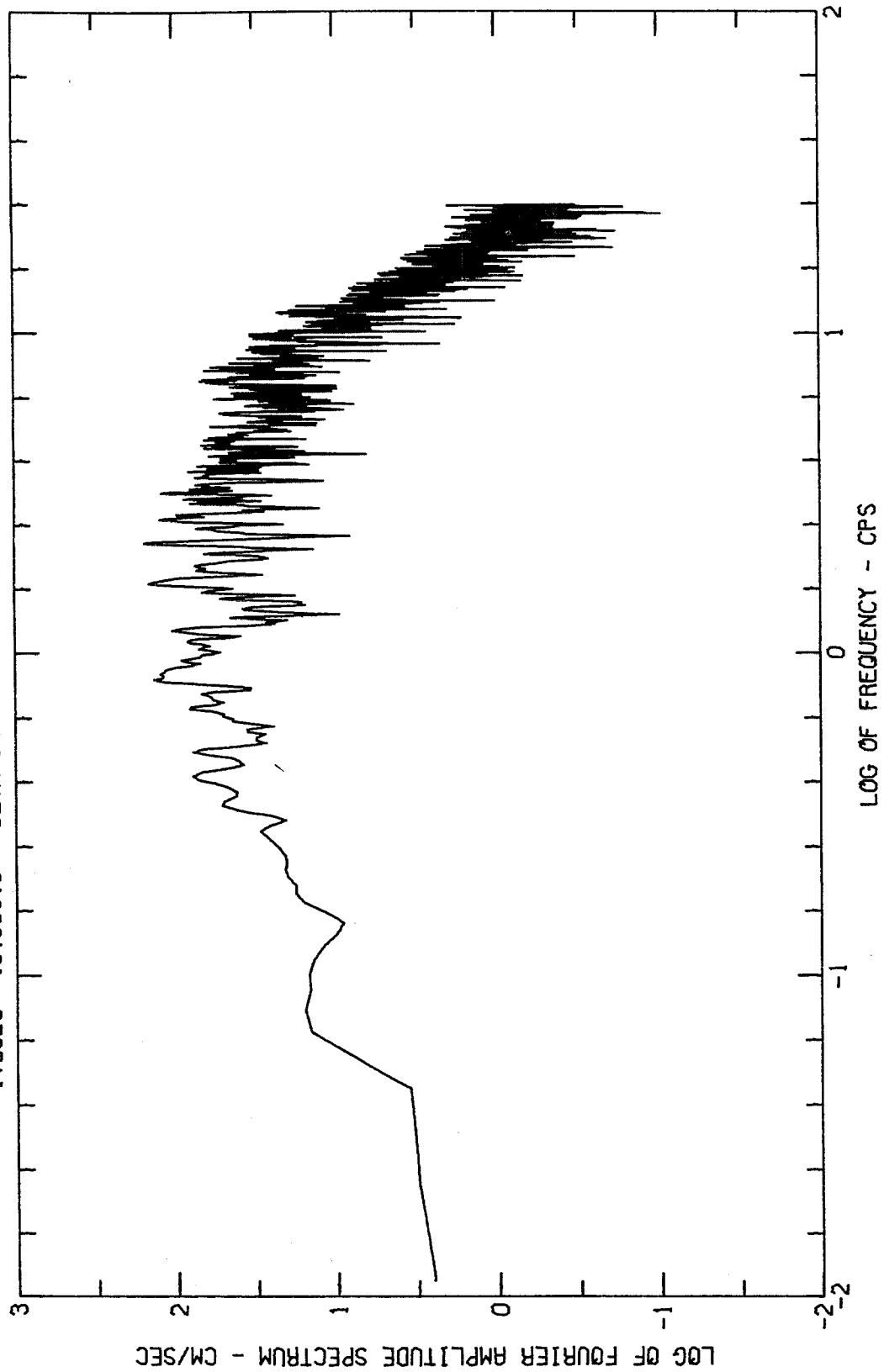
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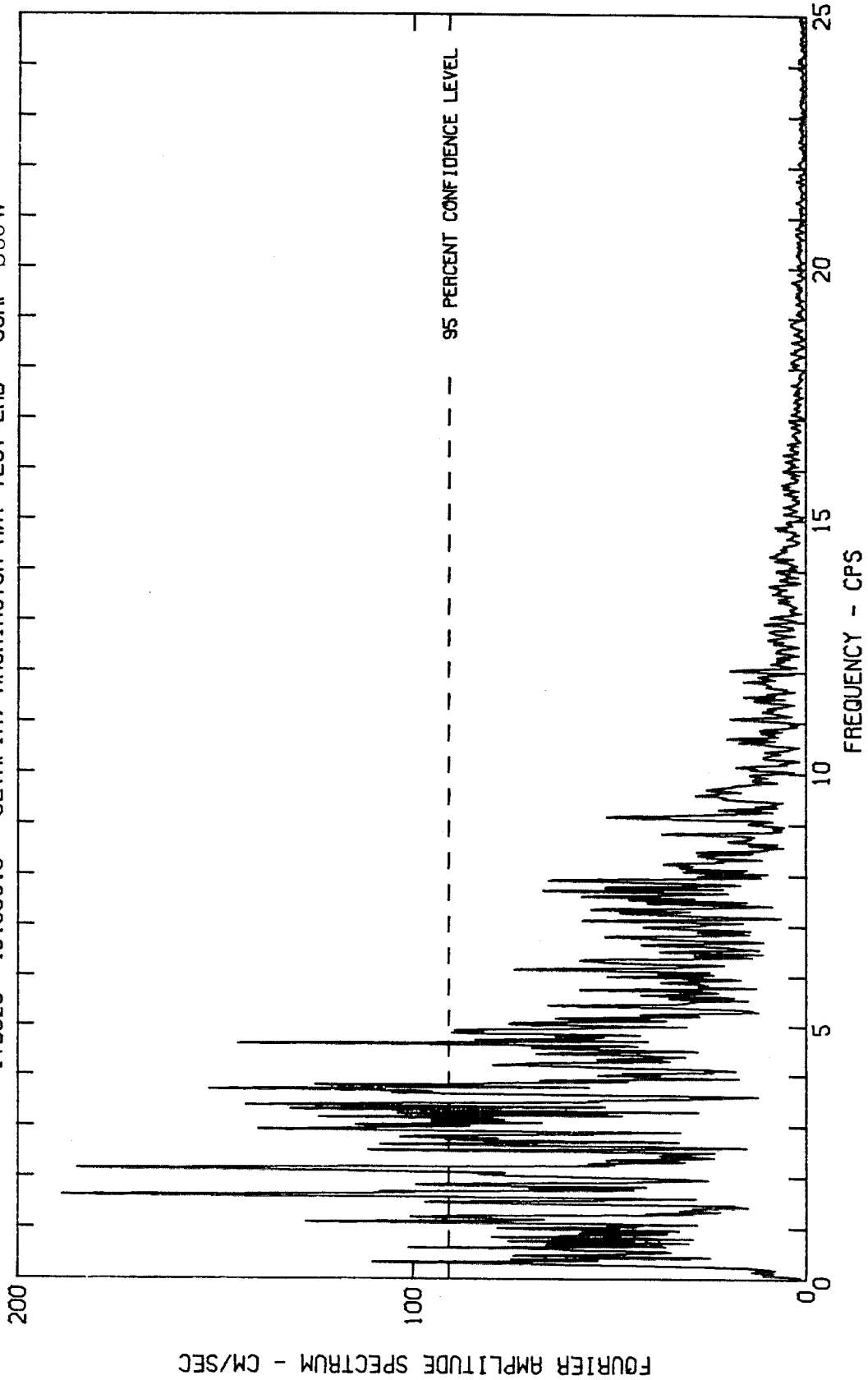
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
WESTERN WASHINGTON EARTHQUAKE APR 13, 1949 - 1156 PST
1V8029 49.003.0 OLYMPIA, WASHINGTON HWY TEST LAB COMP S04E



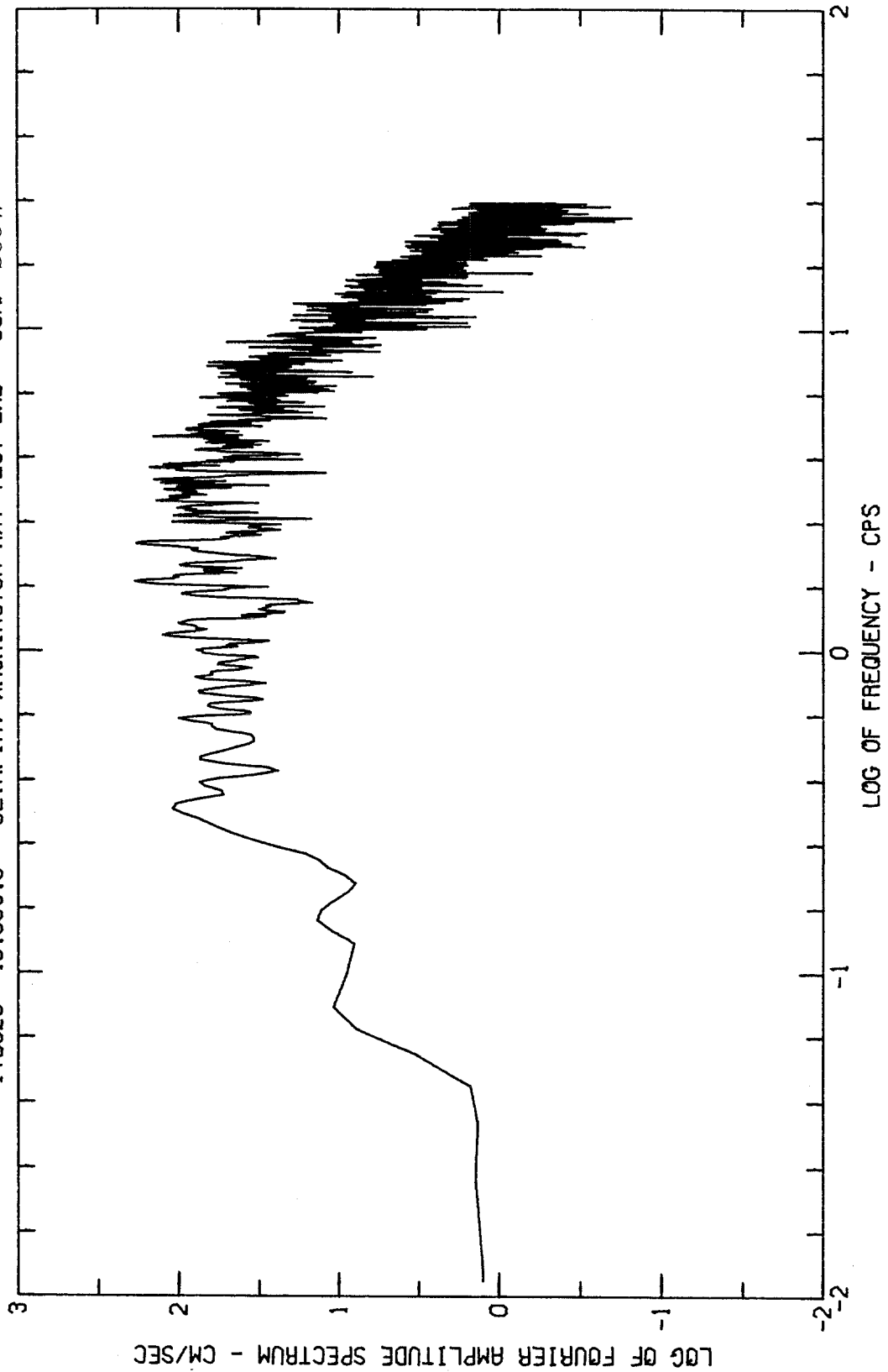
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IVB029 49.003.0 OLYMPIA, WASHINGTON HWY TEST LAB COMP S04E



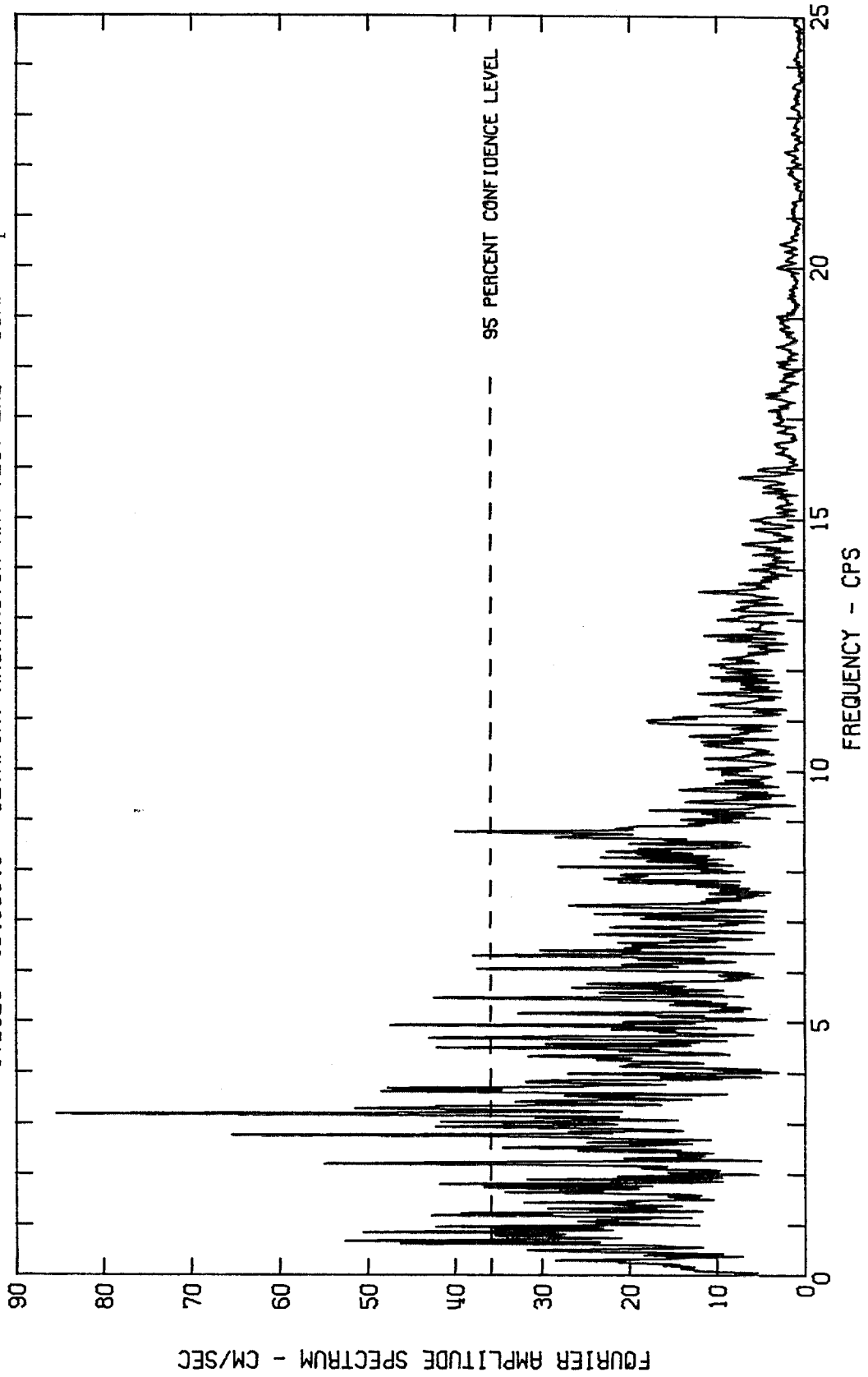
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
WESTERN WASHINGTON EARTHQUAKE APR 13, 1949 - 1156 PST
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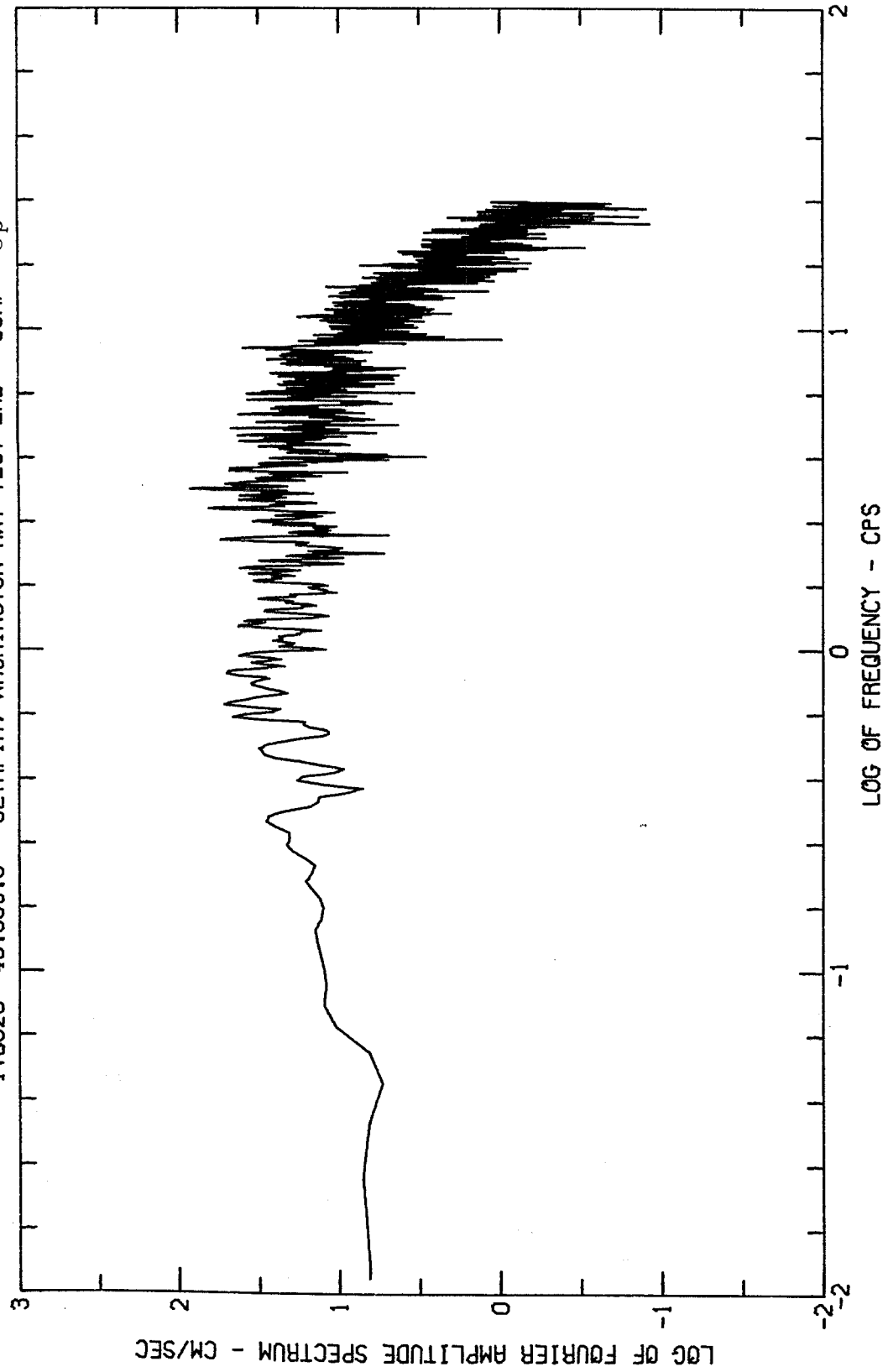
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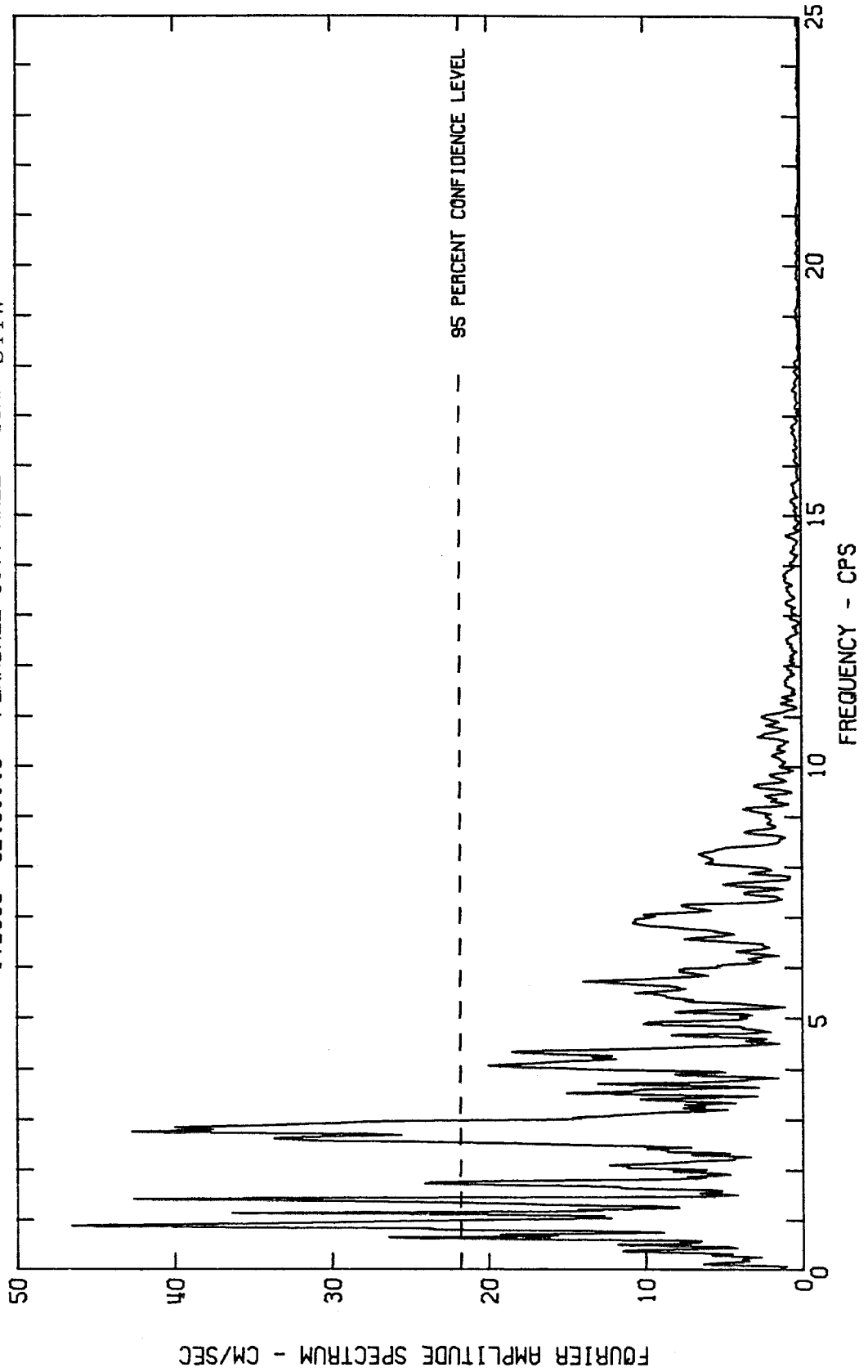
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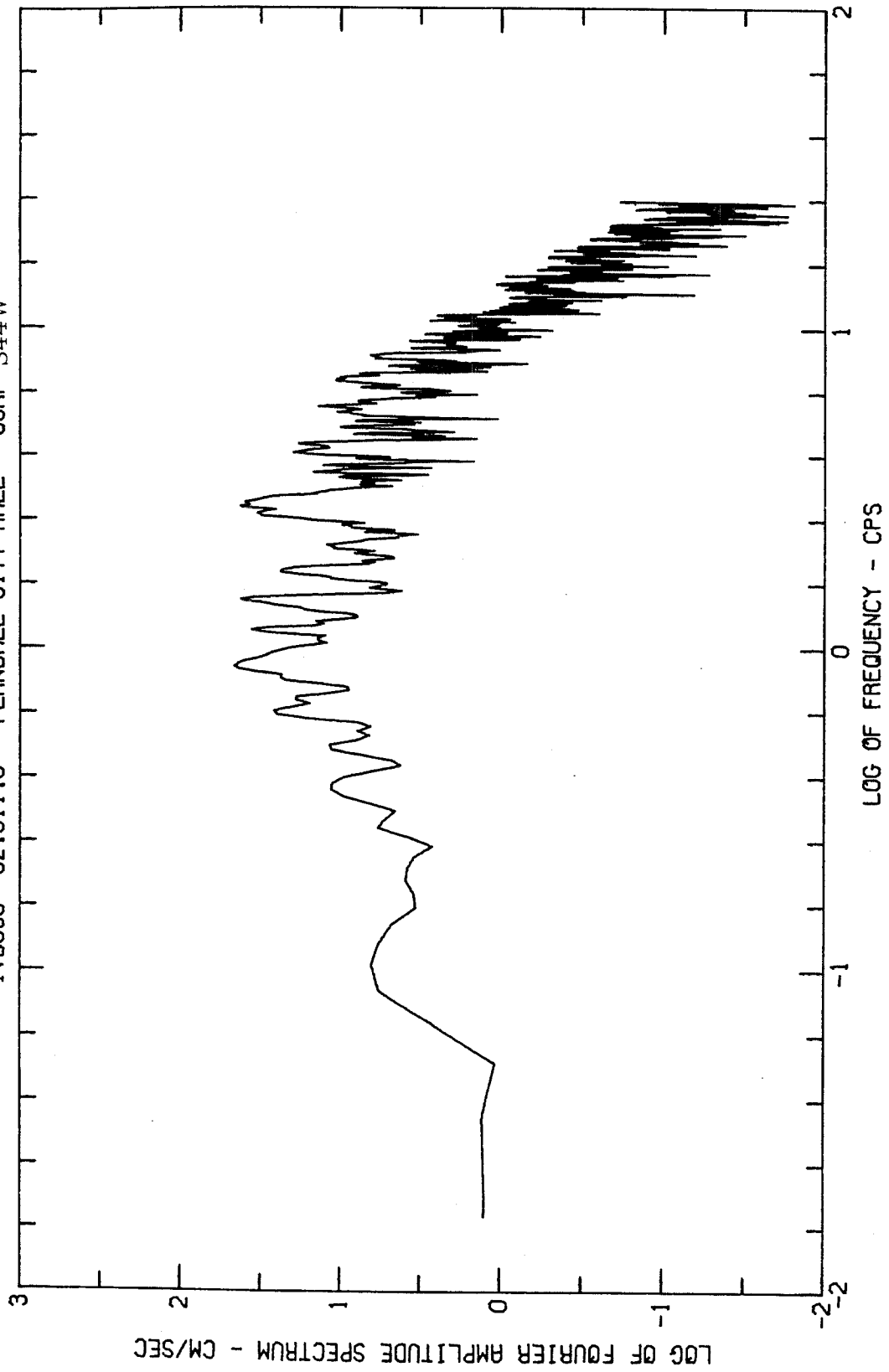
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
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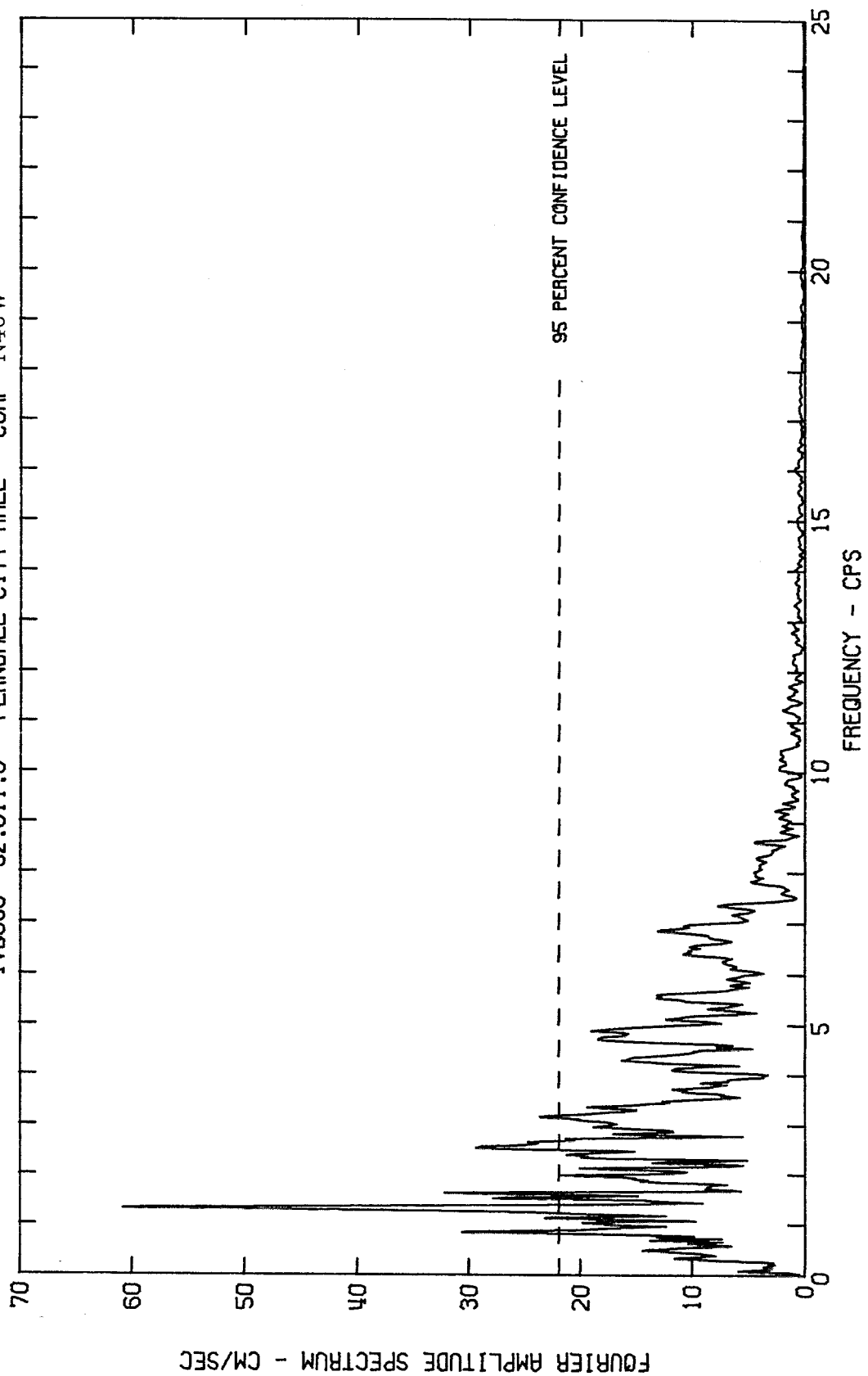
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
NORTHERN CALIFORNIA EARTHQUAKE SEPT 22, 1952 - 0441 PDT
1VB030 52.011.0 FERDALE CITY HALL COMP S44W



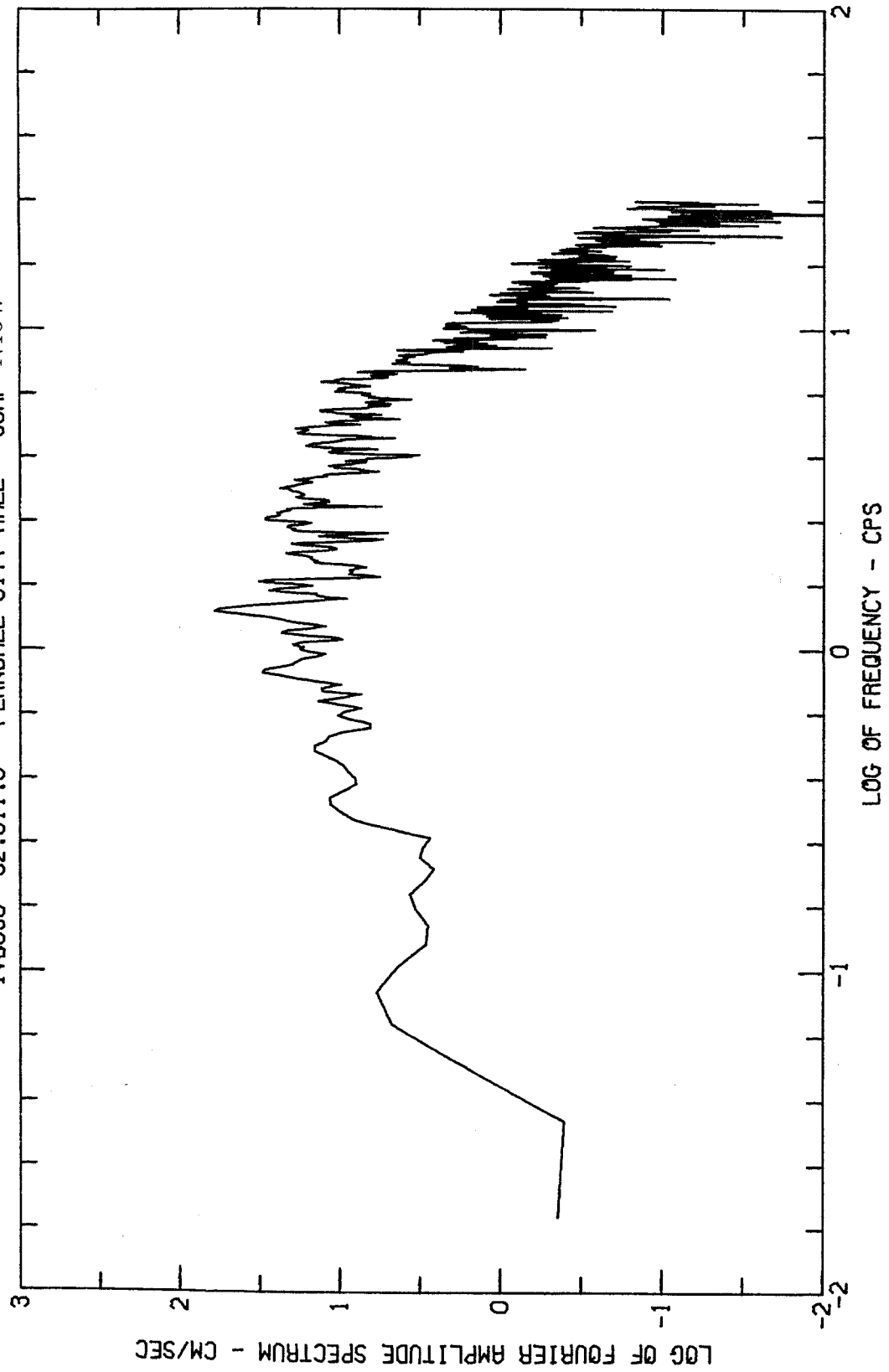
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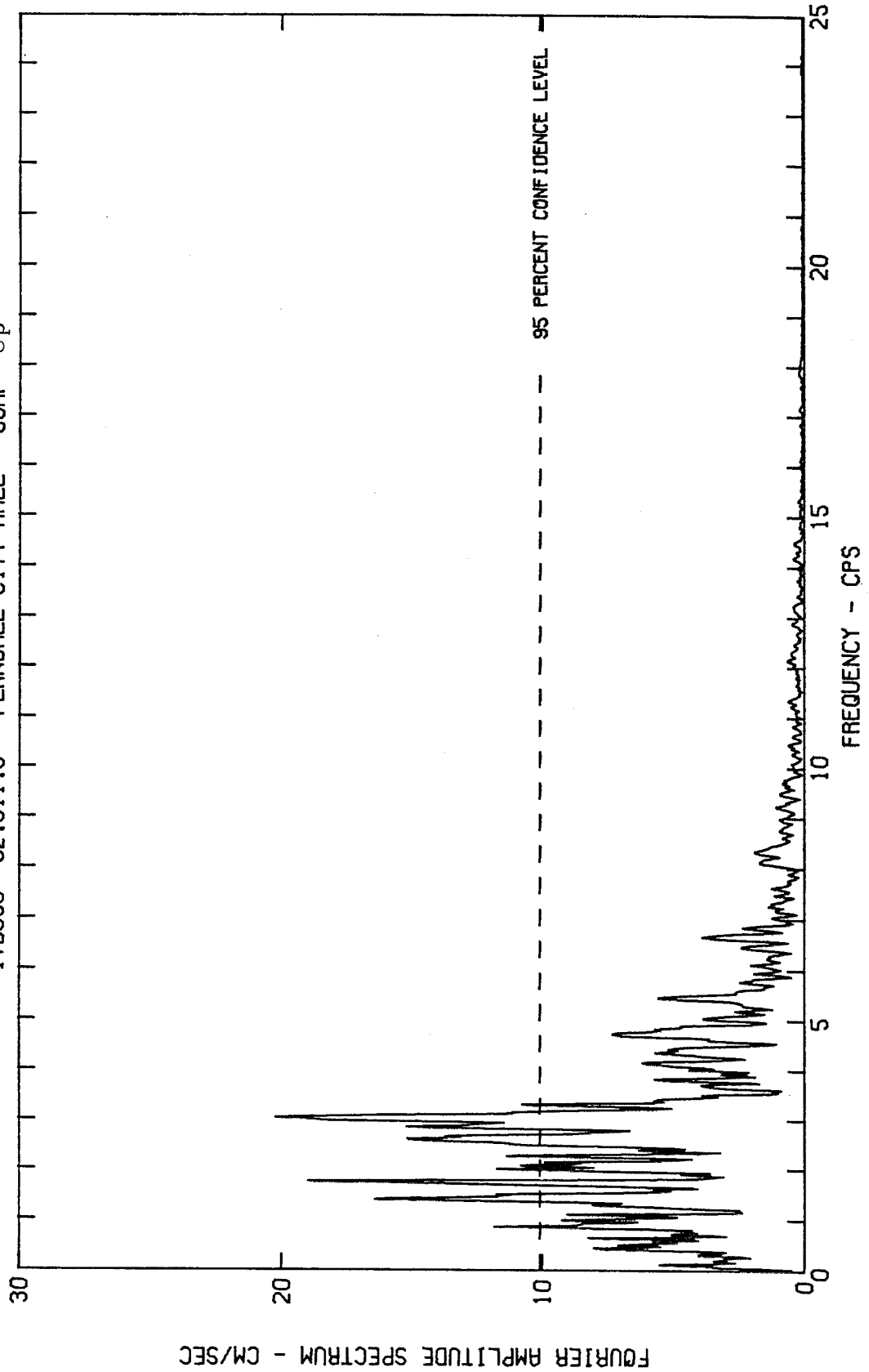
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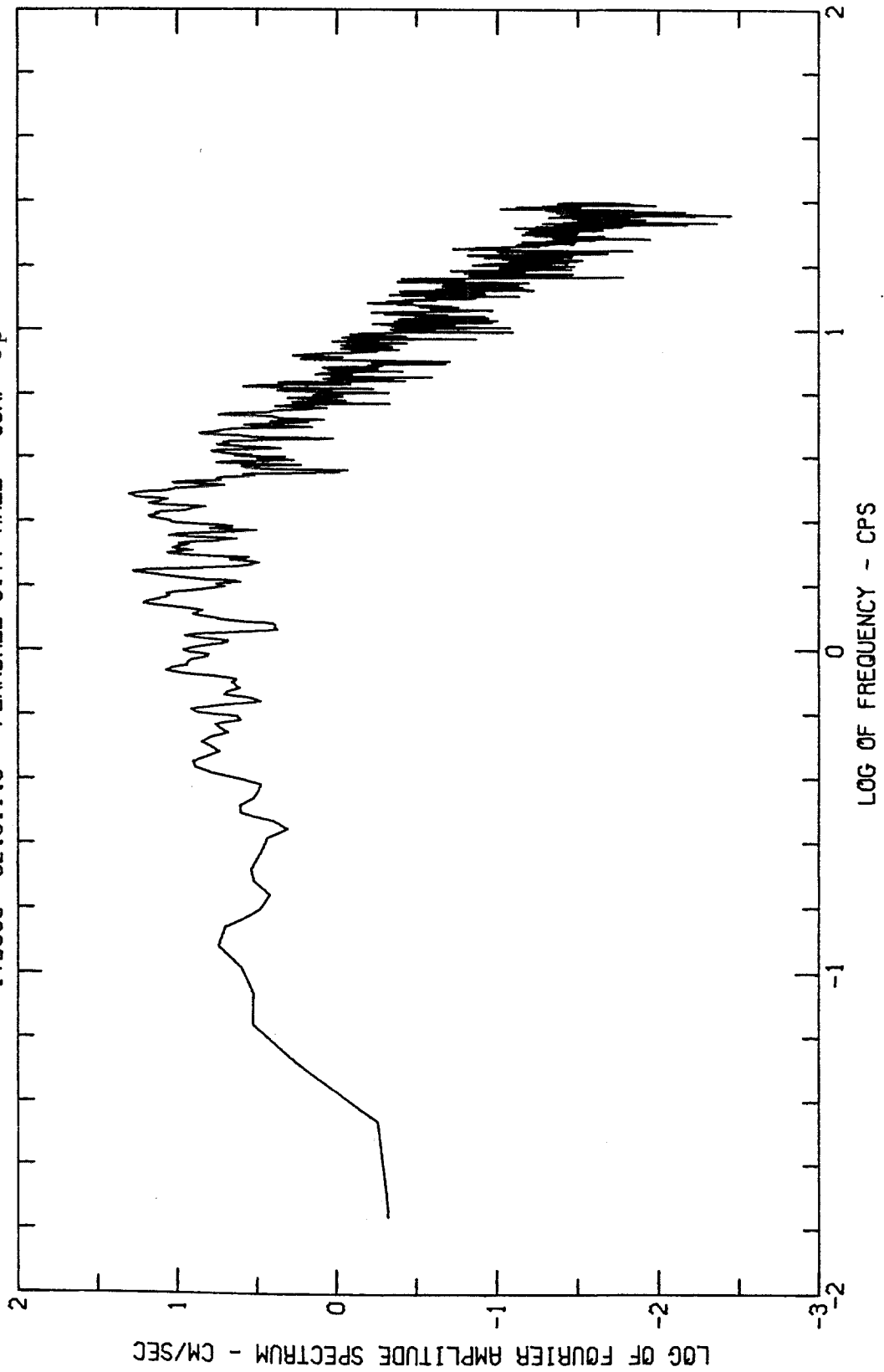
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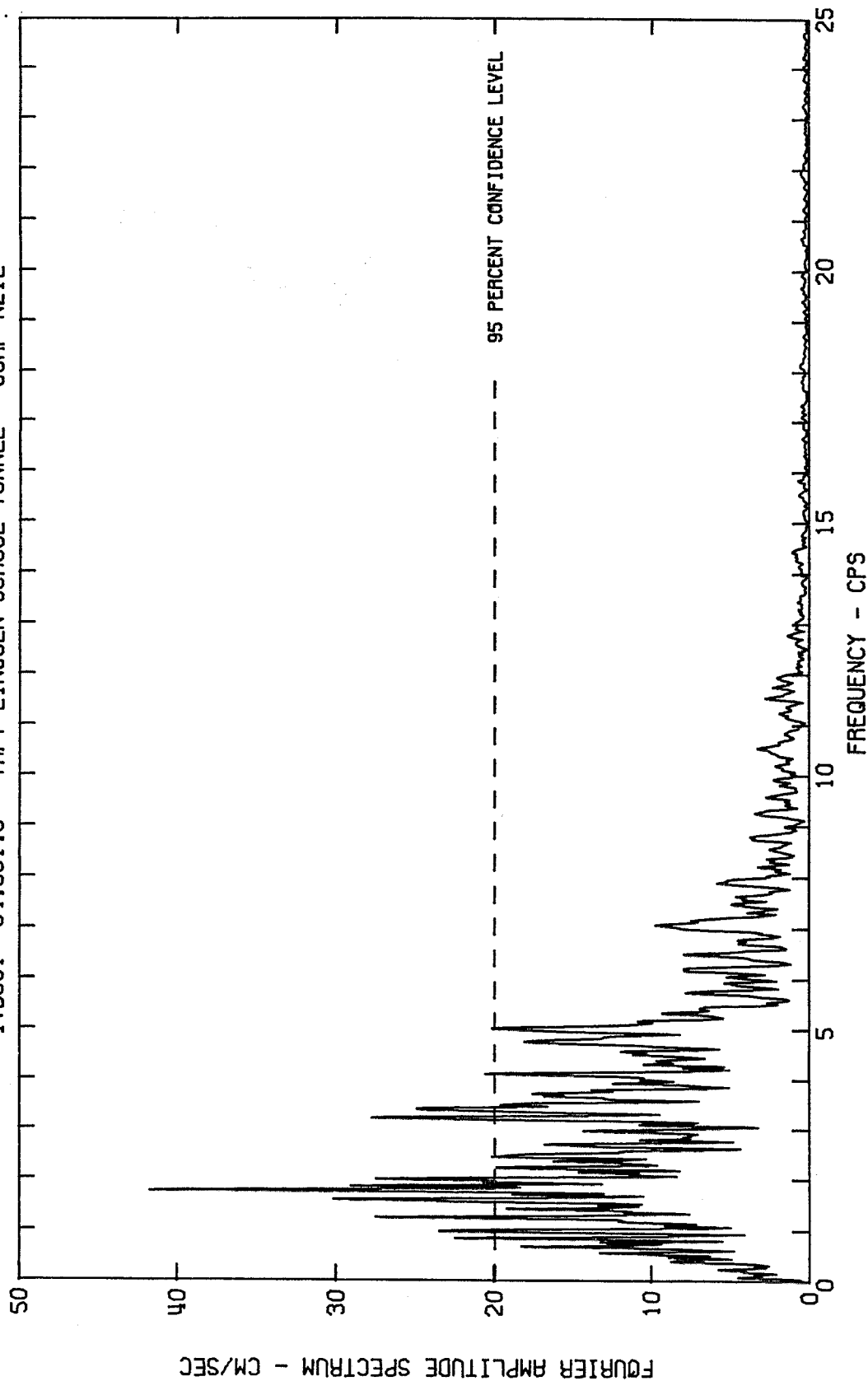
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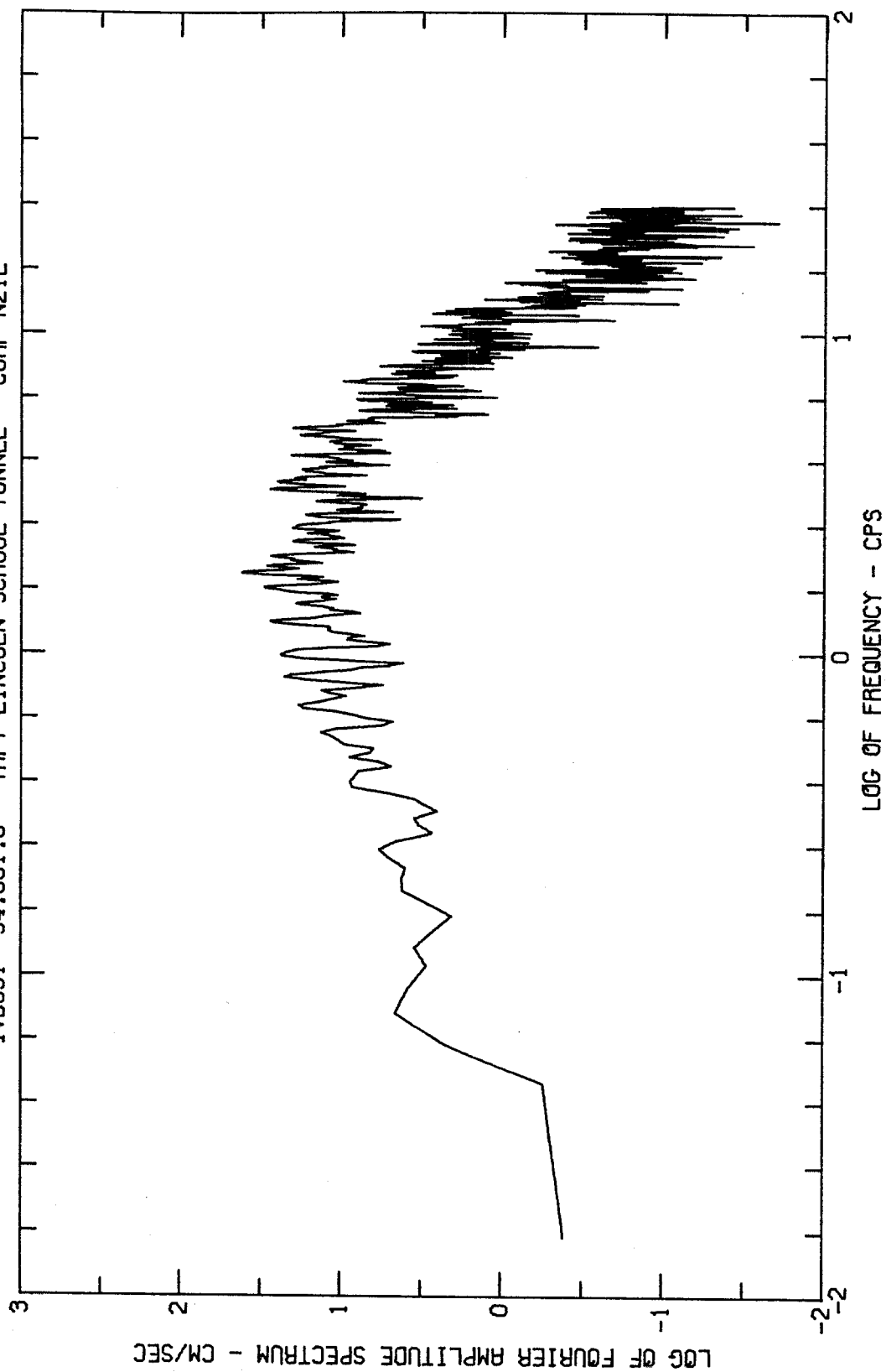
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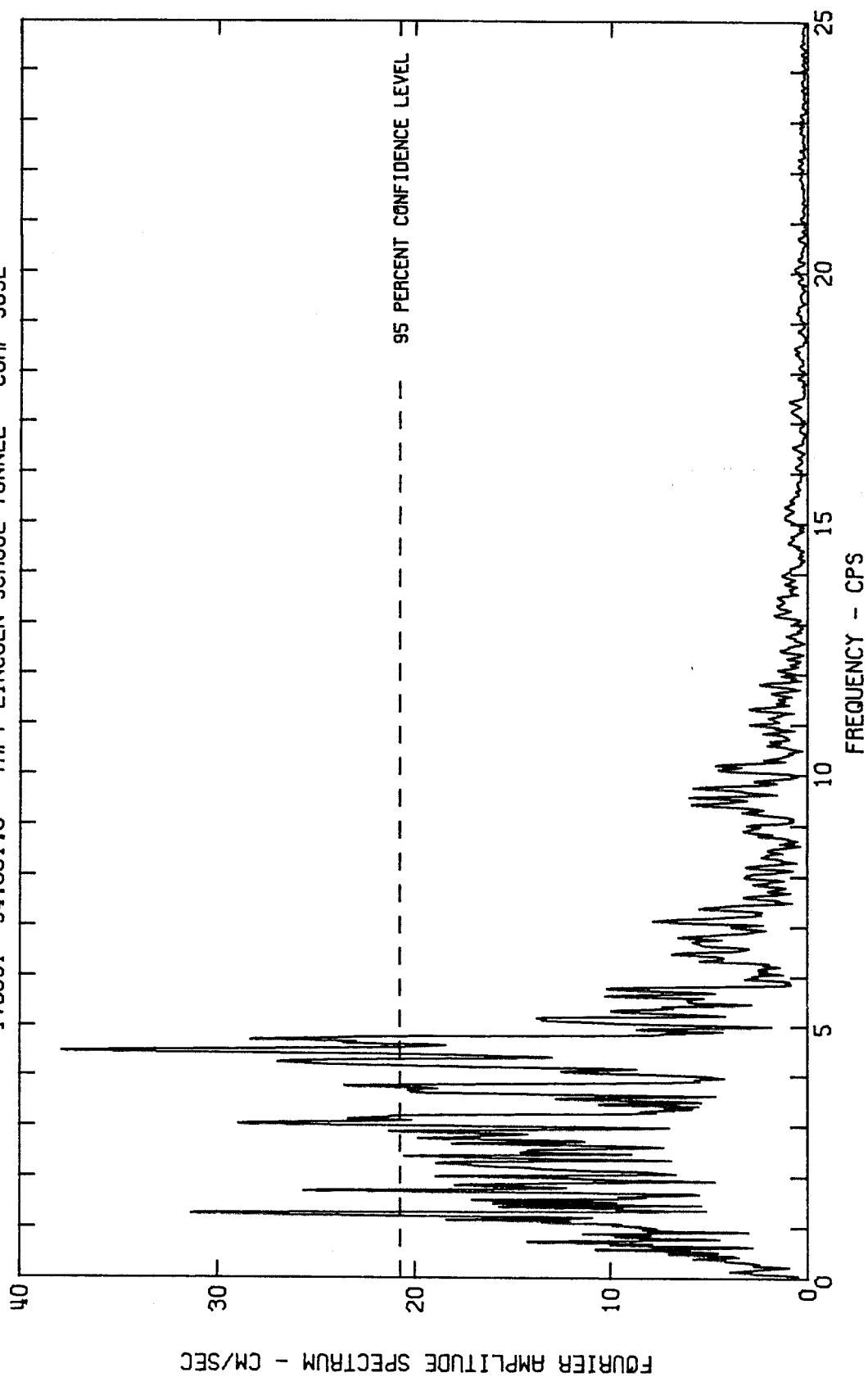
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
WHEELER RIDGE, CALIFORNIA EARTHQUAKE JAN 12, 1954 - 1534 PST
IVB031 54.001.0 TAFT LINCOLN SCHOOL TUNNEL COMP N21E



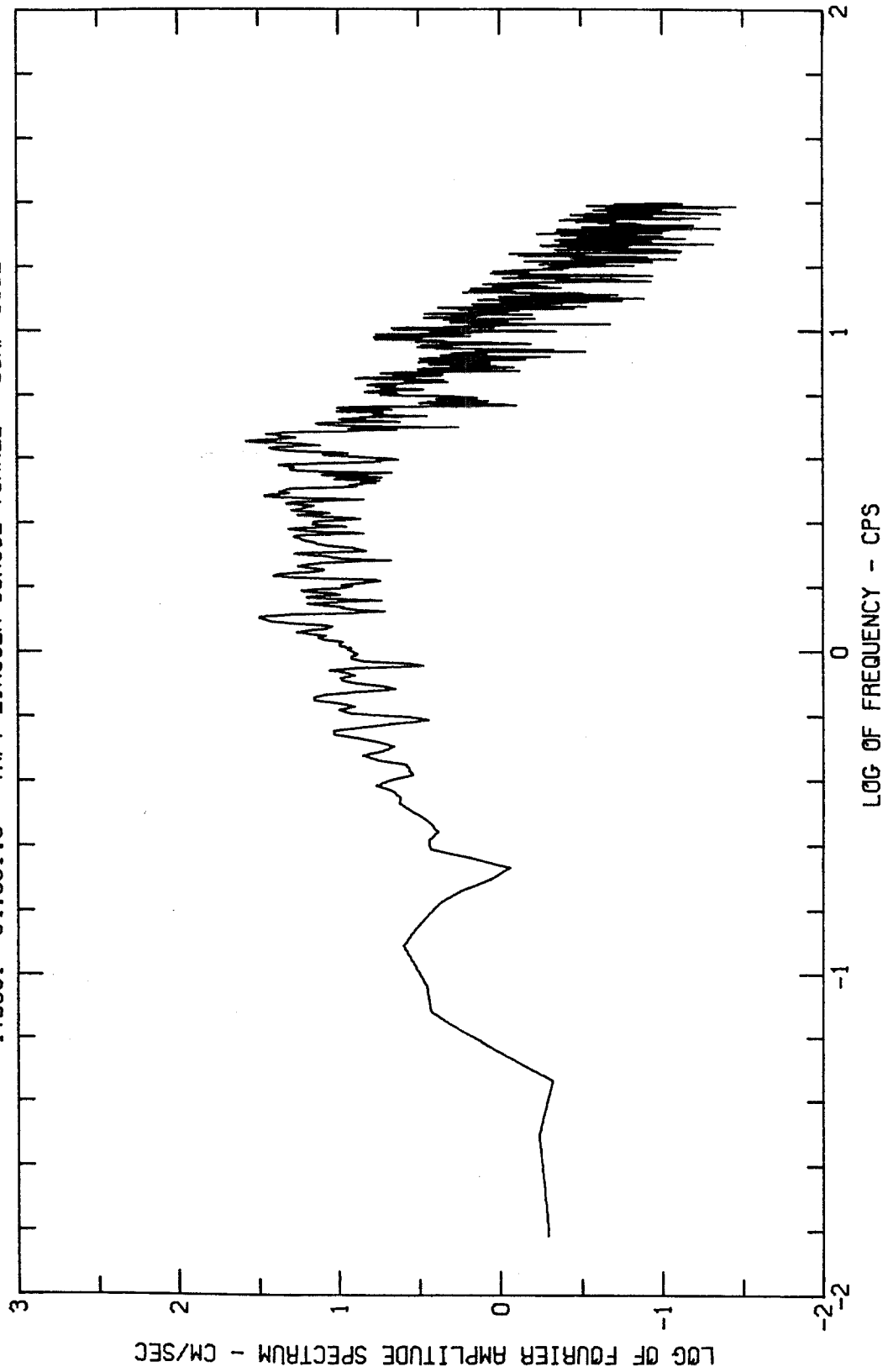
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
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IV8031 54.001.0 TAFT LINCOLN SCHOOL TUNNEL COMP N21E



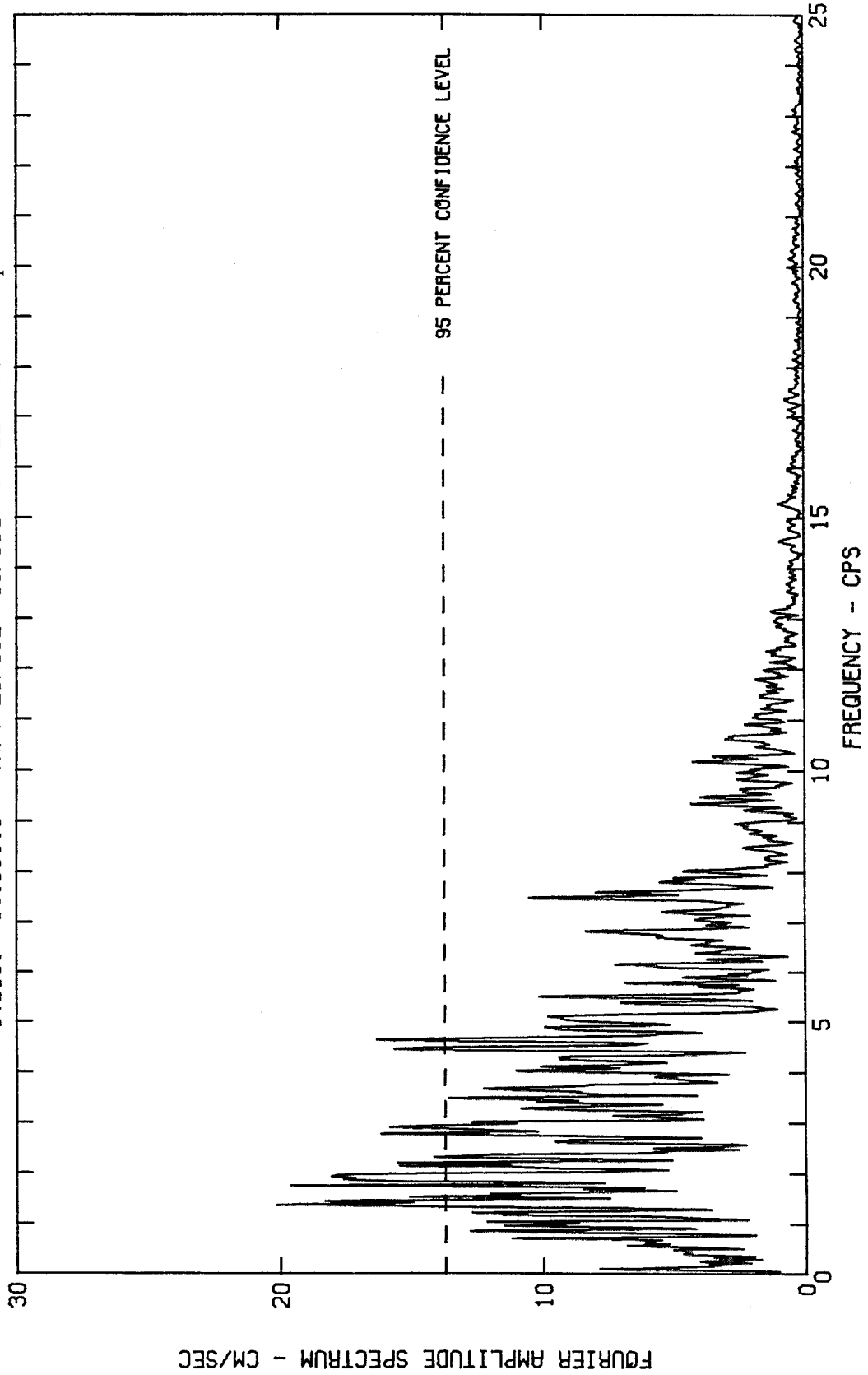
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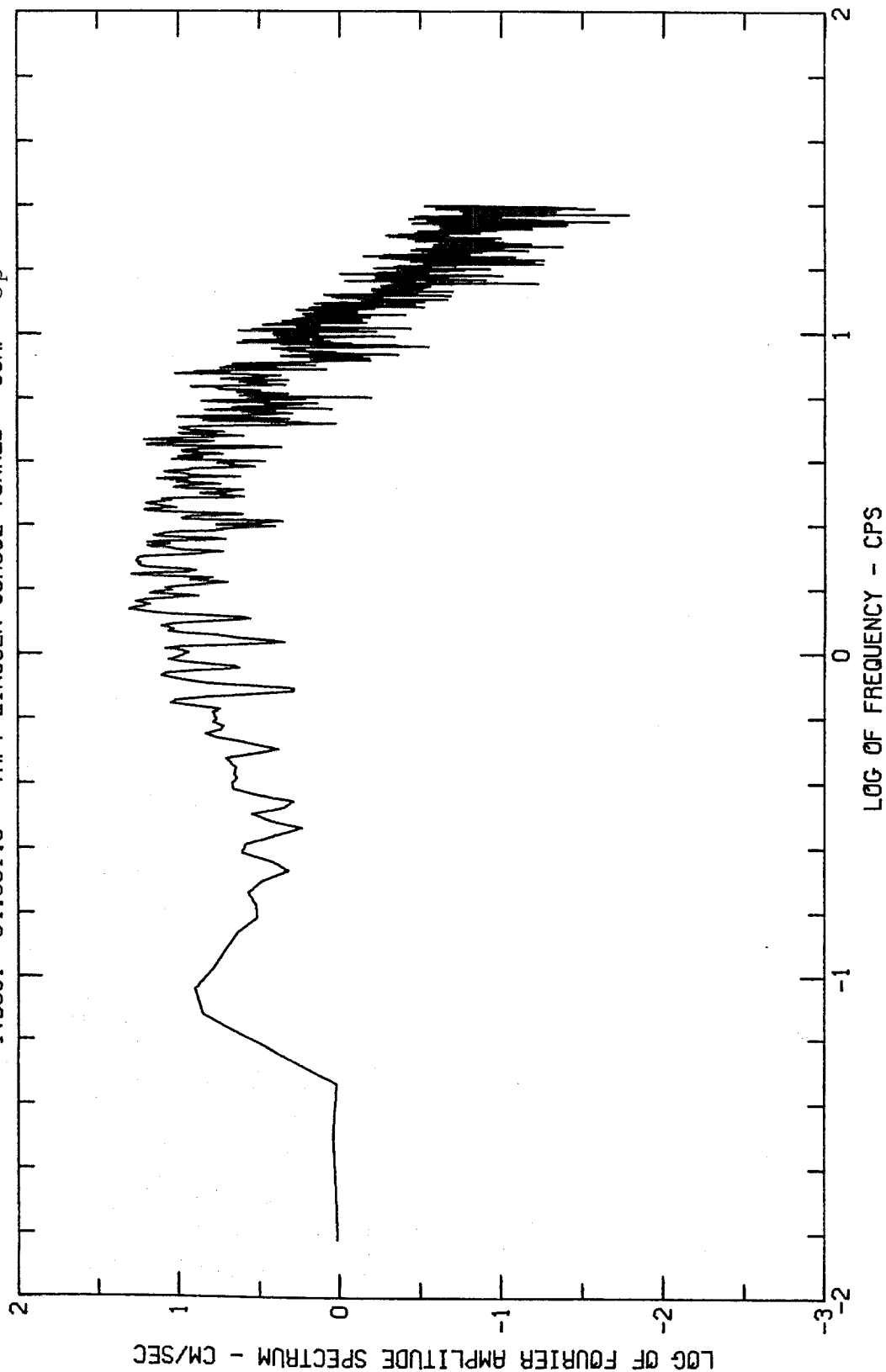
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1VB031 54.001.0 TAFT LINCOLN SCHOOL TUNNEL COMP S69E



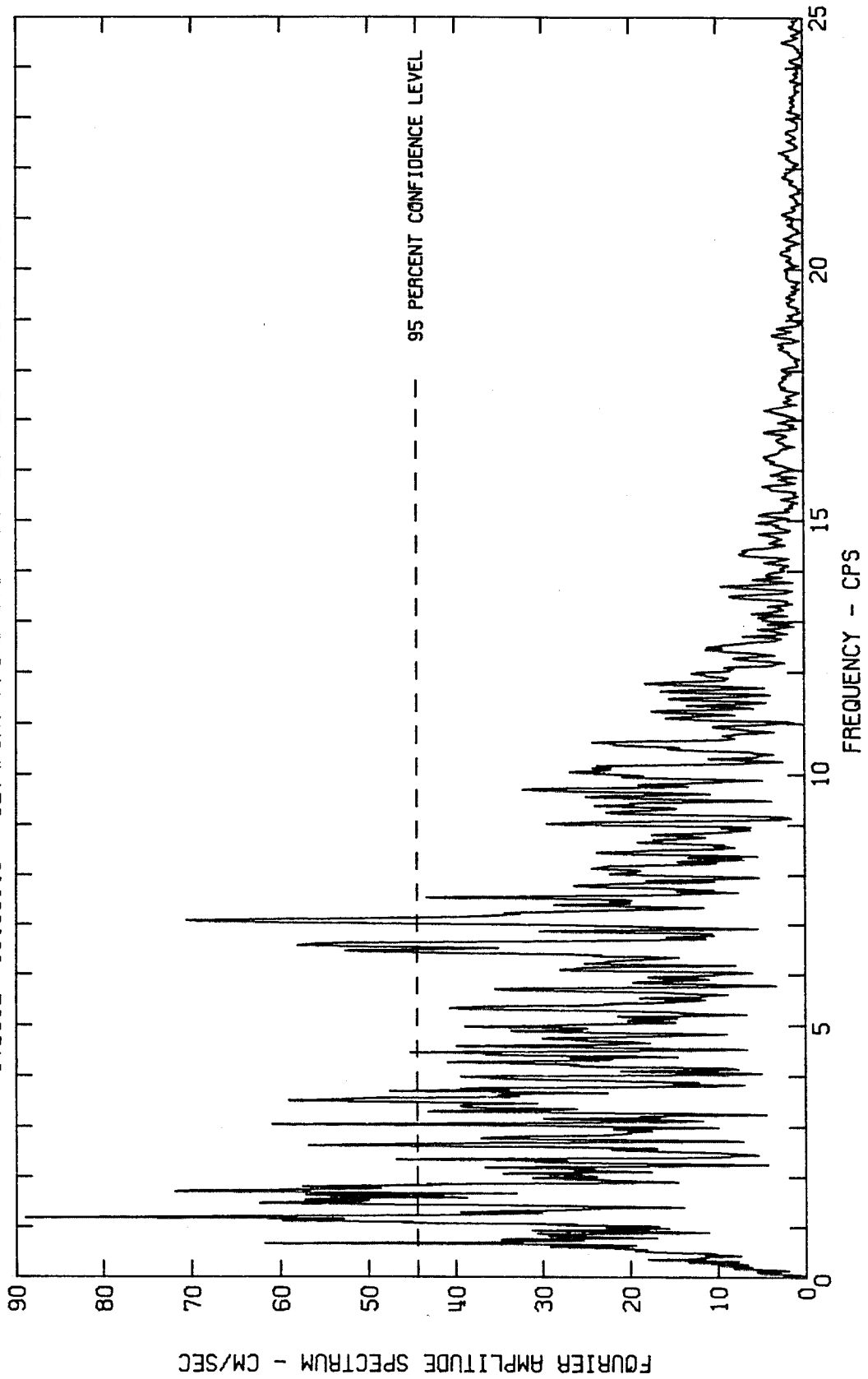
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IV8031 54.001.0 TAFT LINCOLN SCHOOL TUNNEL COMP Up



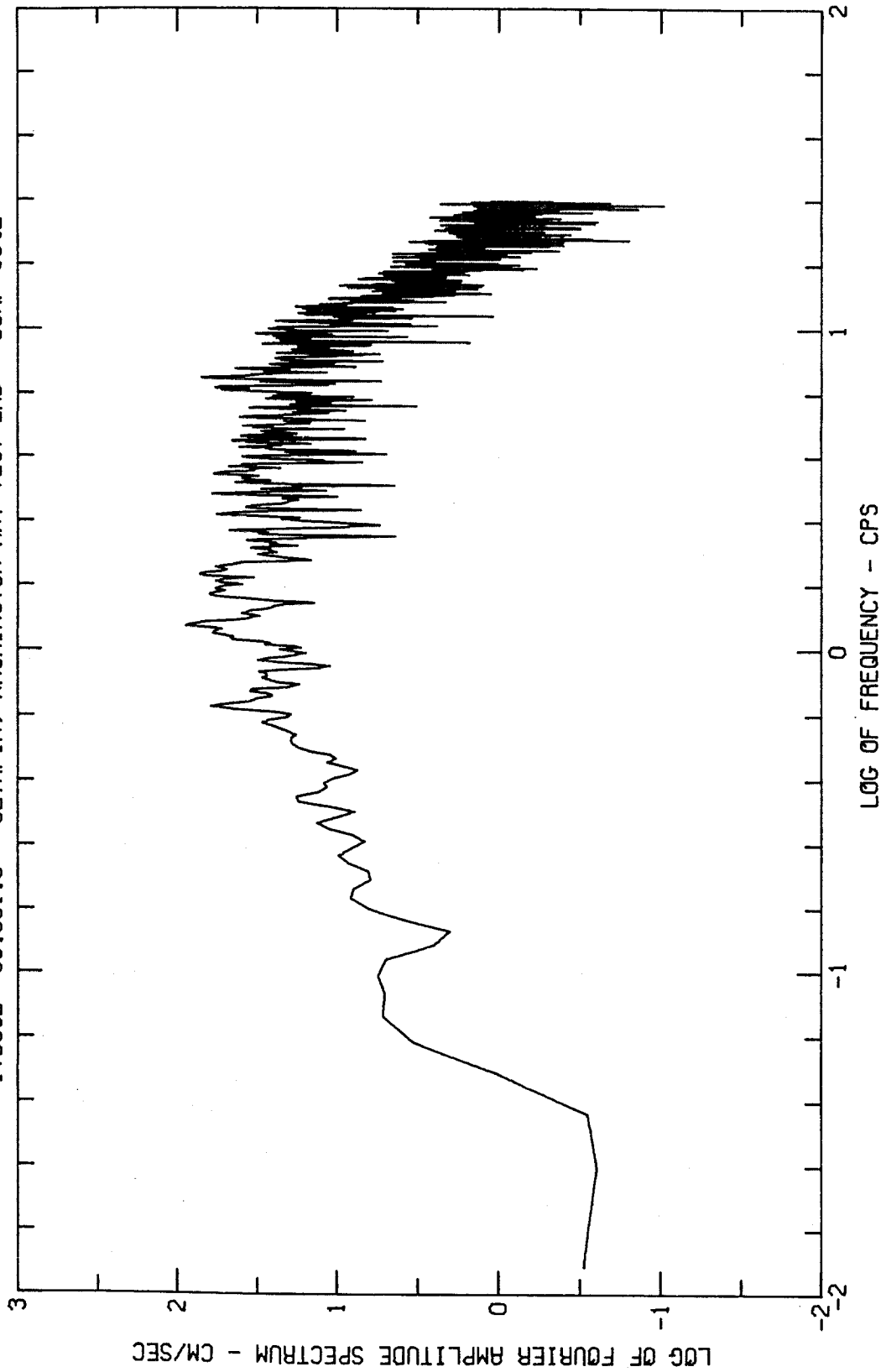
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IVB031 54.001.0 TAFT LINCOLN SCHOOL TUNNEL COMP Up



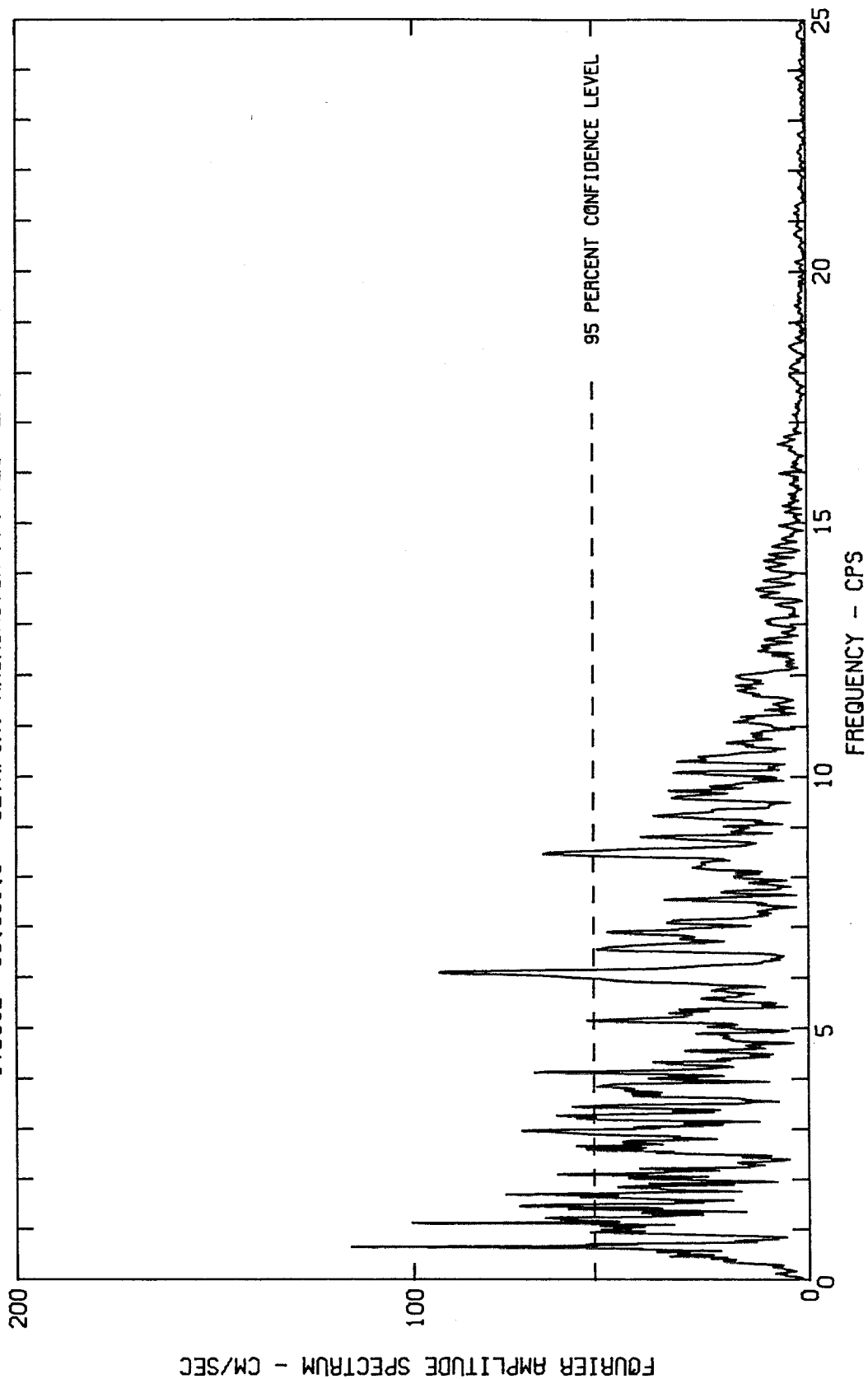
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
PUGET SOUND, WASHINGTON EARTHQUAKE APR 29, 1965 - 0728 PST
IV8032 65.001.0 OLYMPIA, WASHINGTON HWY TEST LAB COMP SO4E



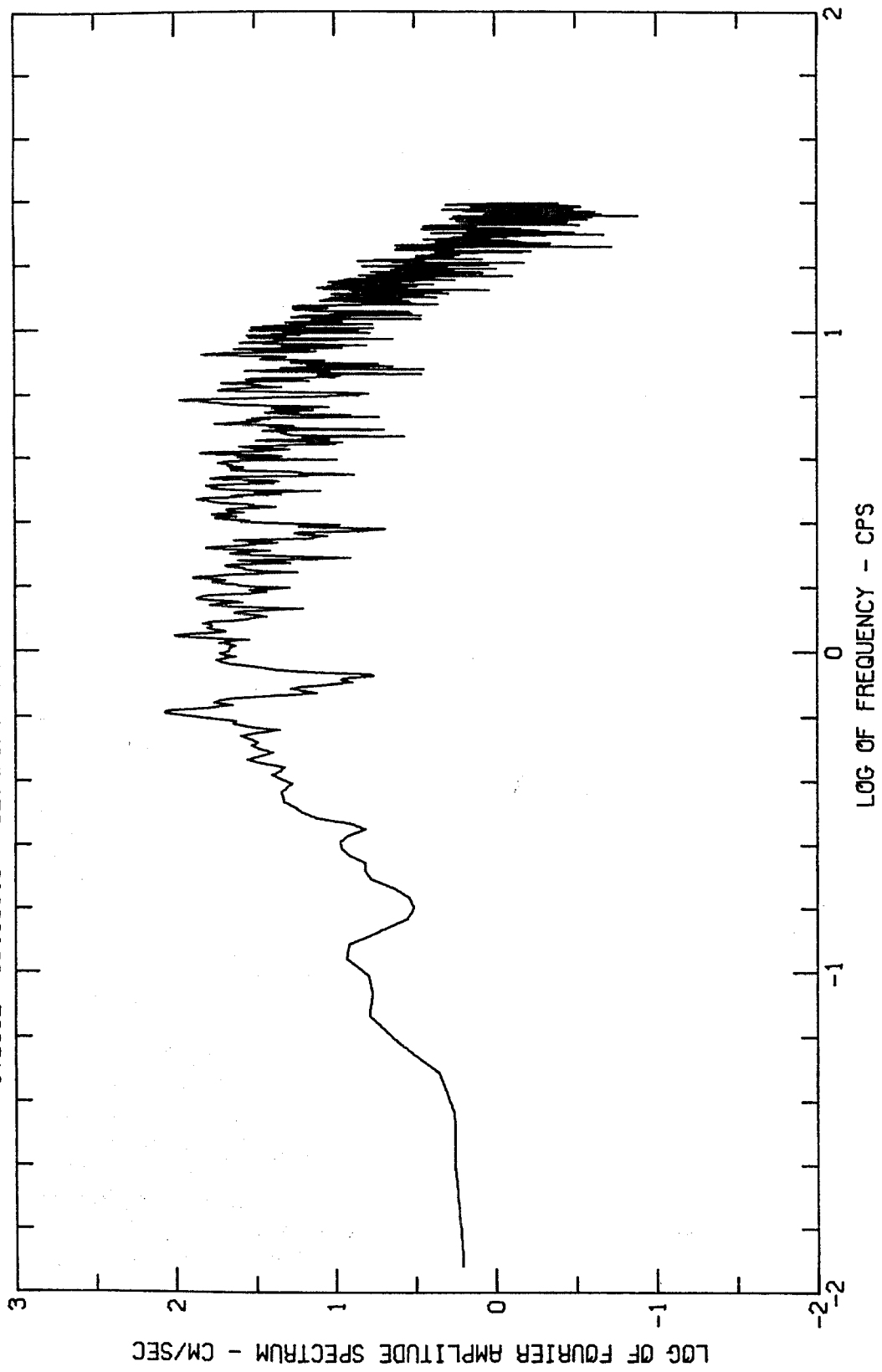
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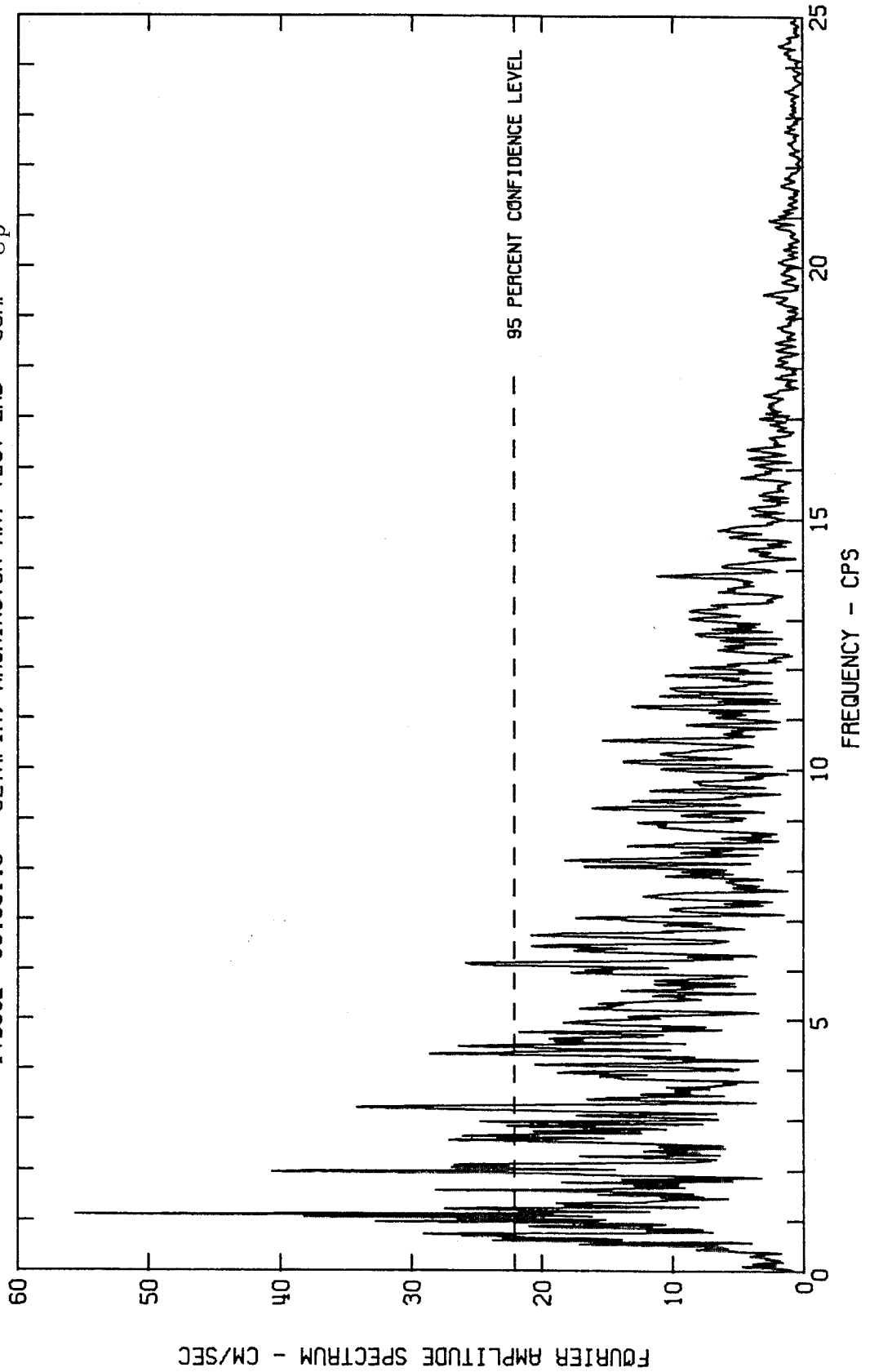
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
PUGET SOUND, WASHINGTON EARTHQUAKE APR 29, 1965 - 0728 PST
IVB032 65.001.0 OLYMPIA, WASHINGTON HWY TEST LAB COMP S86W



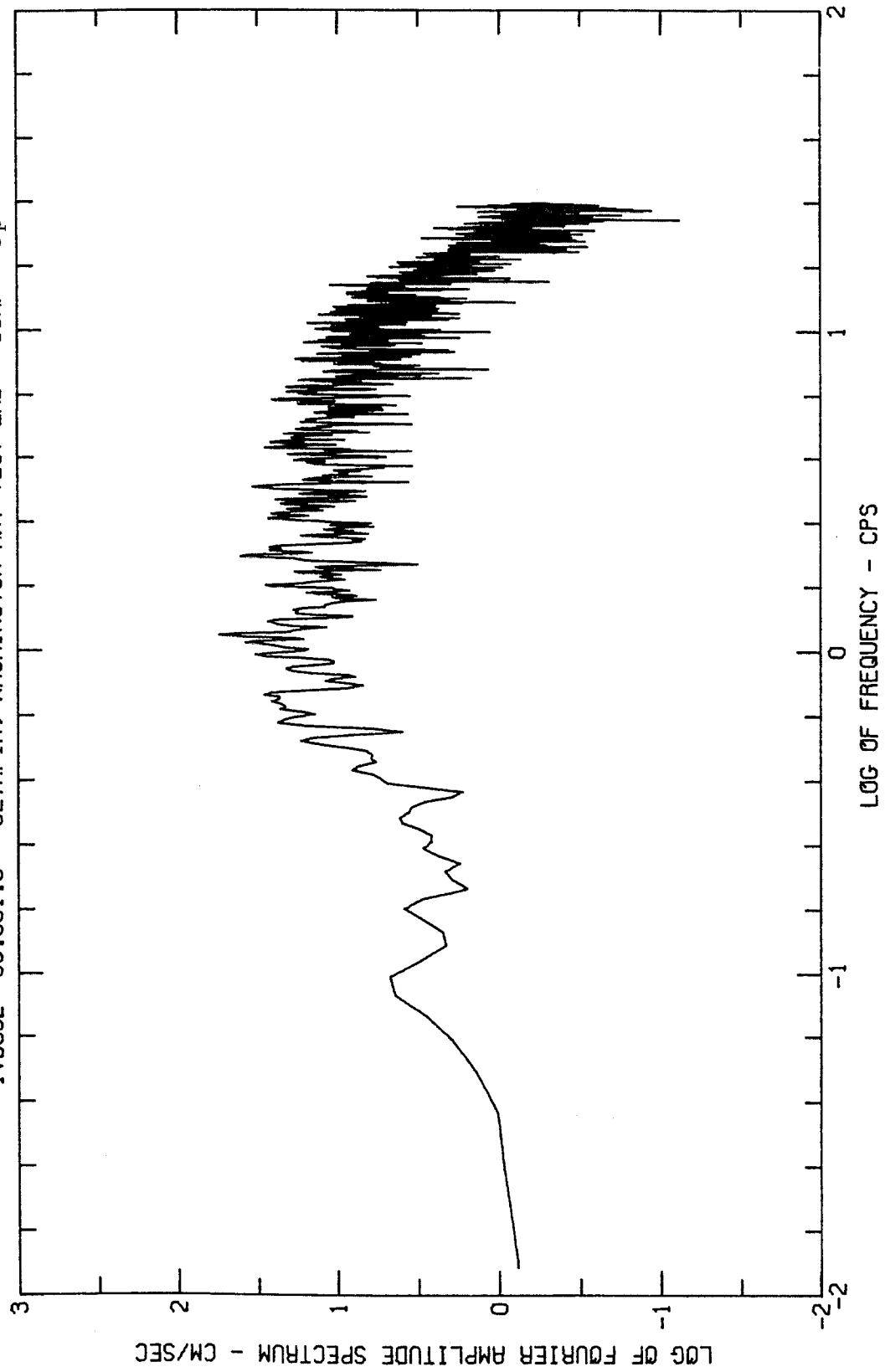
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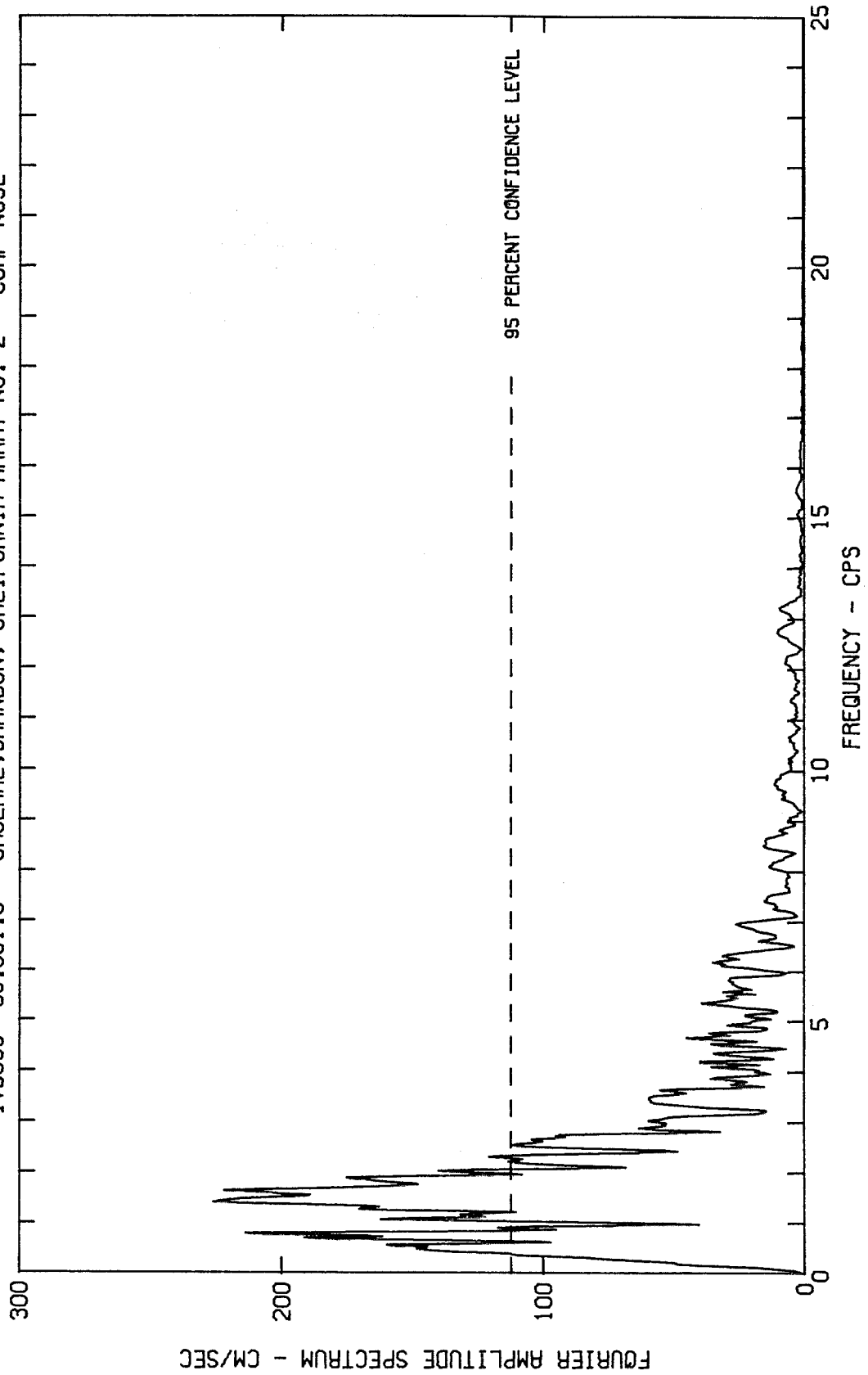
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
PUGET SOUND, WASHINGTON EARTHQUAKE APR 29, 1965 - 0728 PST
IVB032 65.001.0 OLYMPIA, WASHINGTON HWY TEST LAB COMP Up



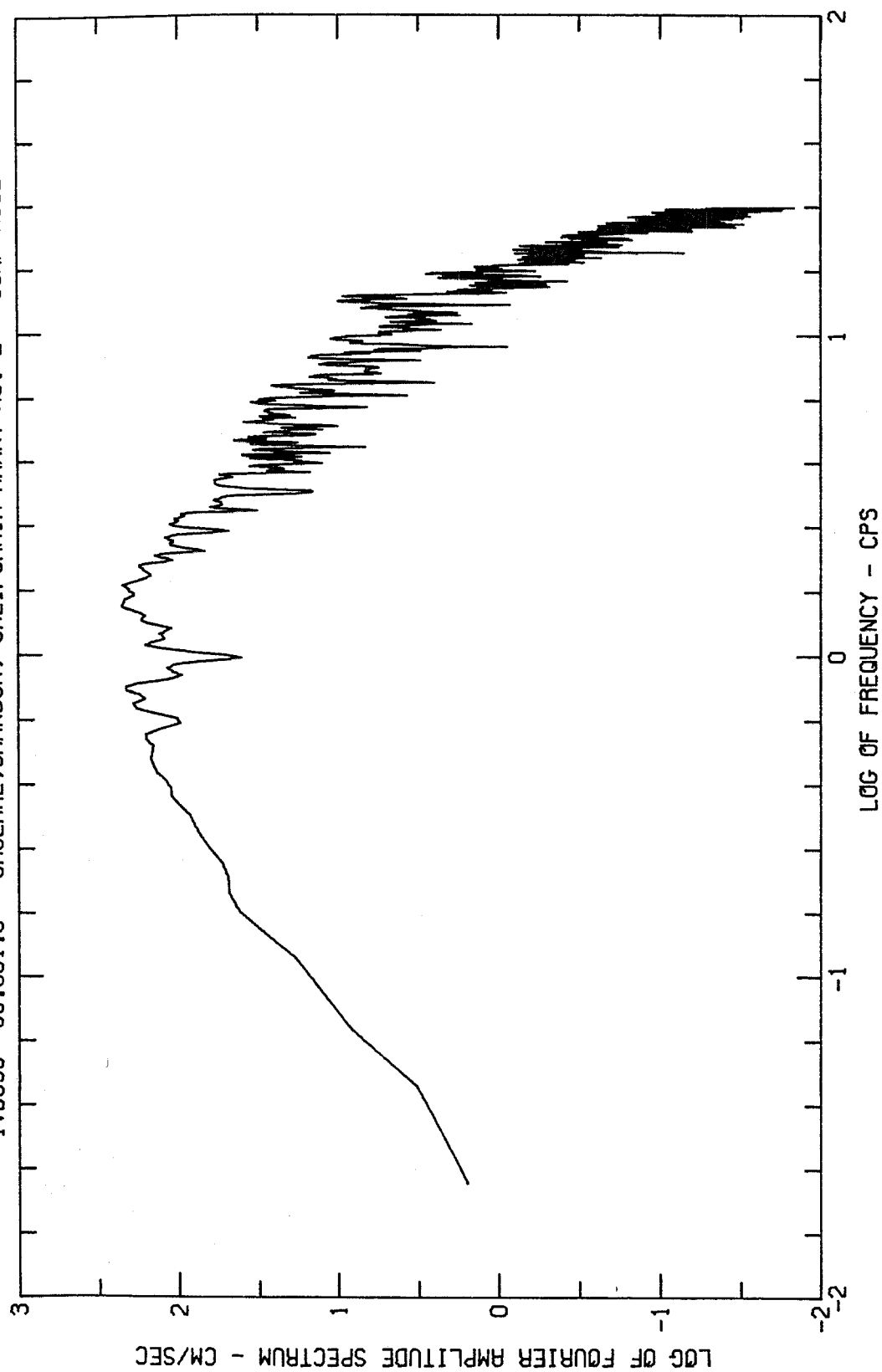
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IVB032 65.001.0 OLYMPIA, WASHINGTON HWY TEST LAB COMP Up



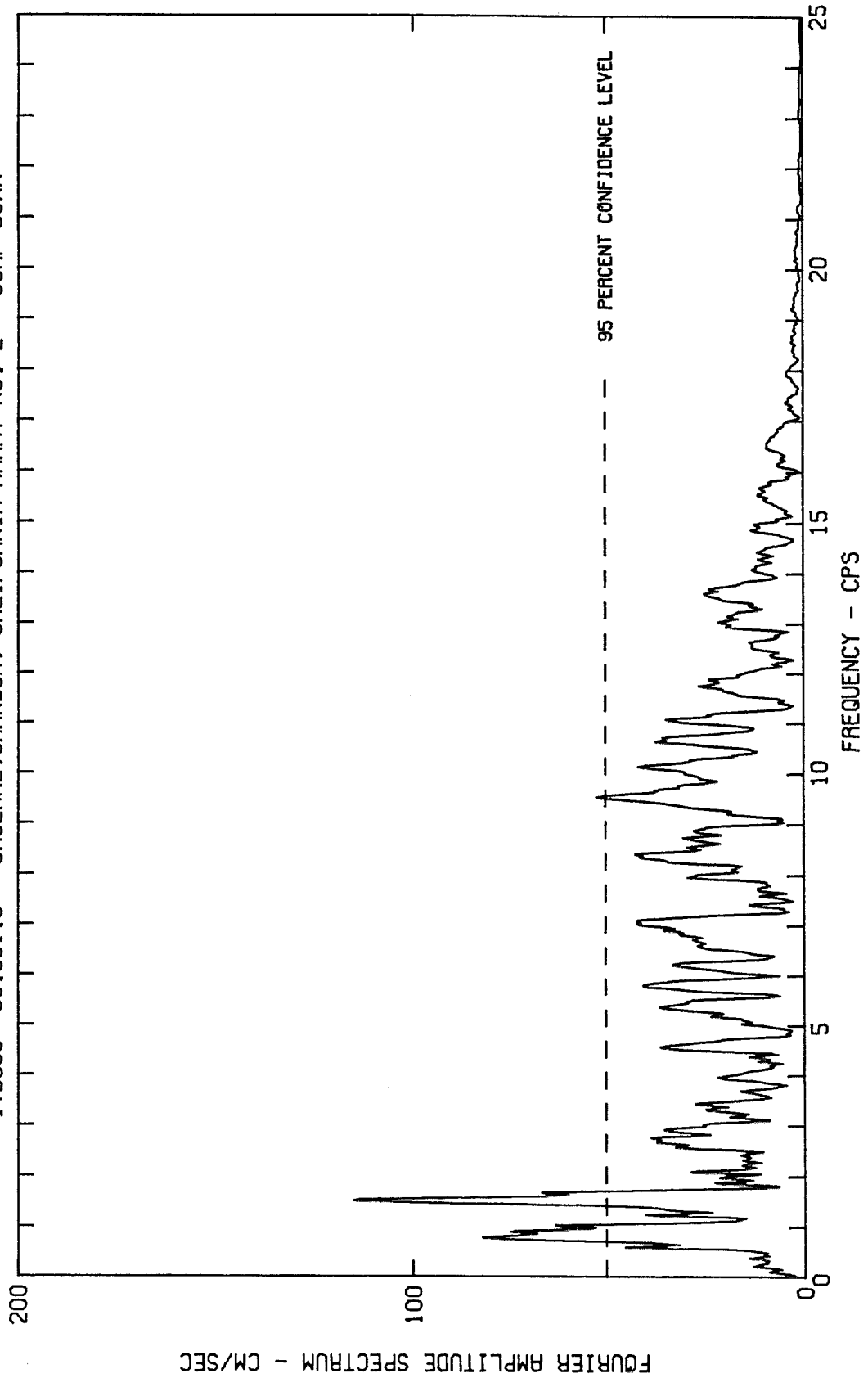
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
PARKFIELD, CALIFORNIA EARTHQUAKE JUNE 27, 1966 - 2026 PST
IVB033 66.001.0 CHOLAME, SHANDON, CALIFORNIA ARRAY NO. 2 COMP N65E



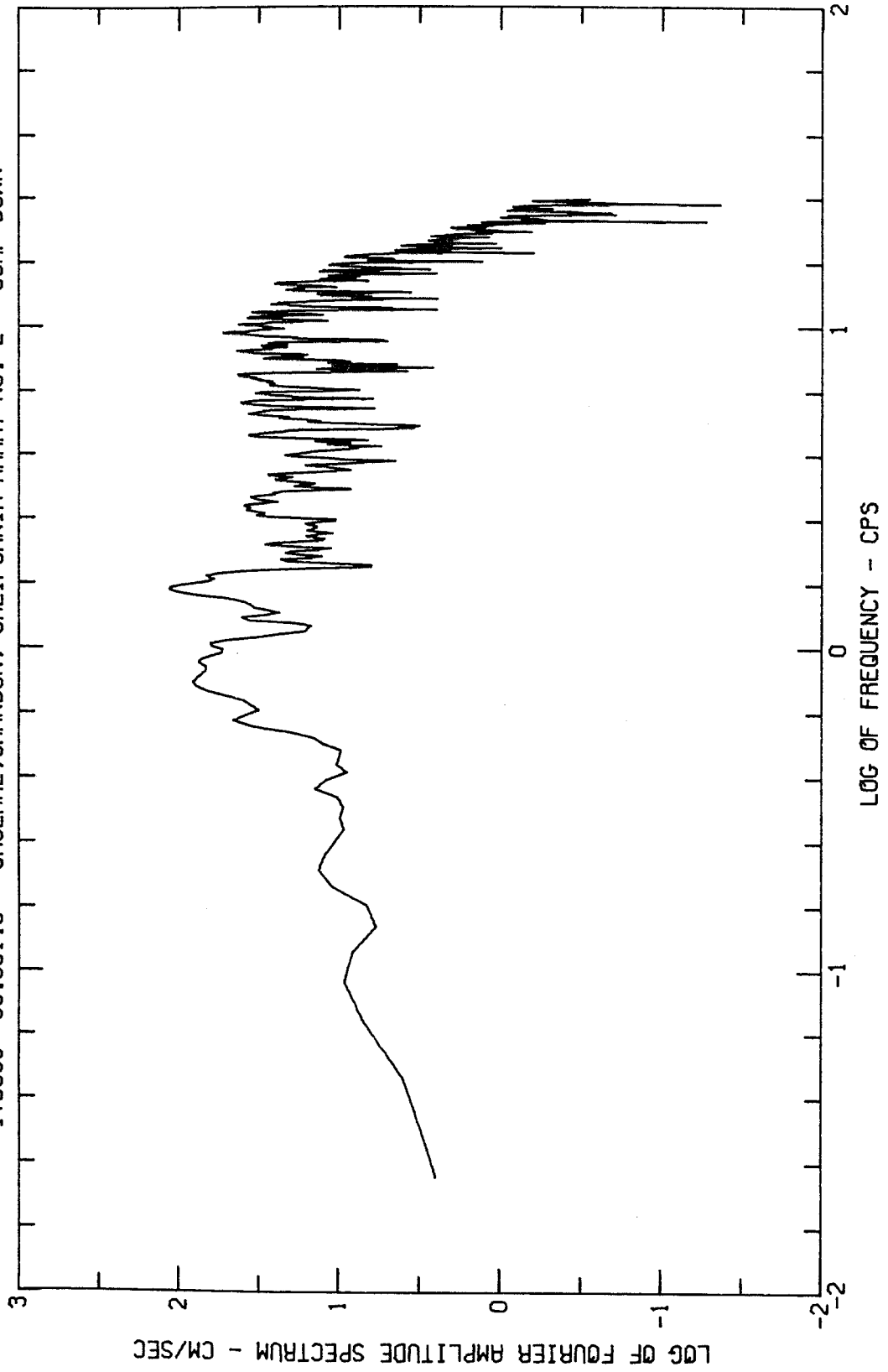
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
PARKFIELD, CALIFORNIA EARTHQUAKE JUNE 27, 1966 - 2026 PST
IV8033 66.001.0 CHOLAME, SHANDON, CALIFORNIA ARRAY NO. 2 COMP N65E



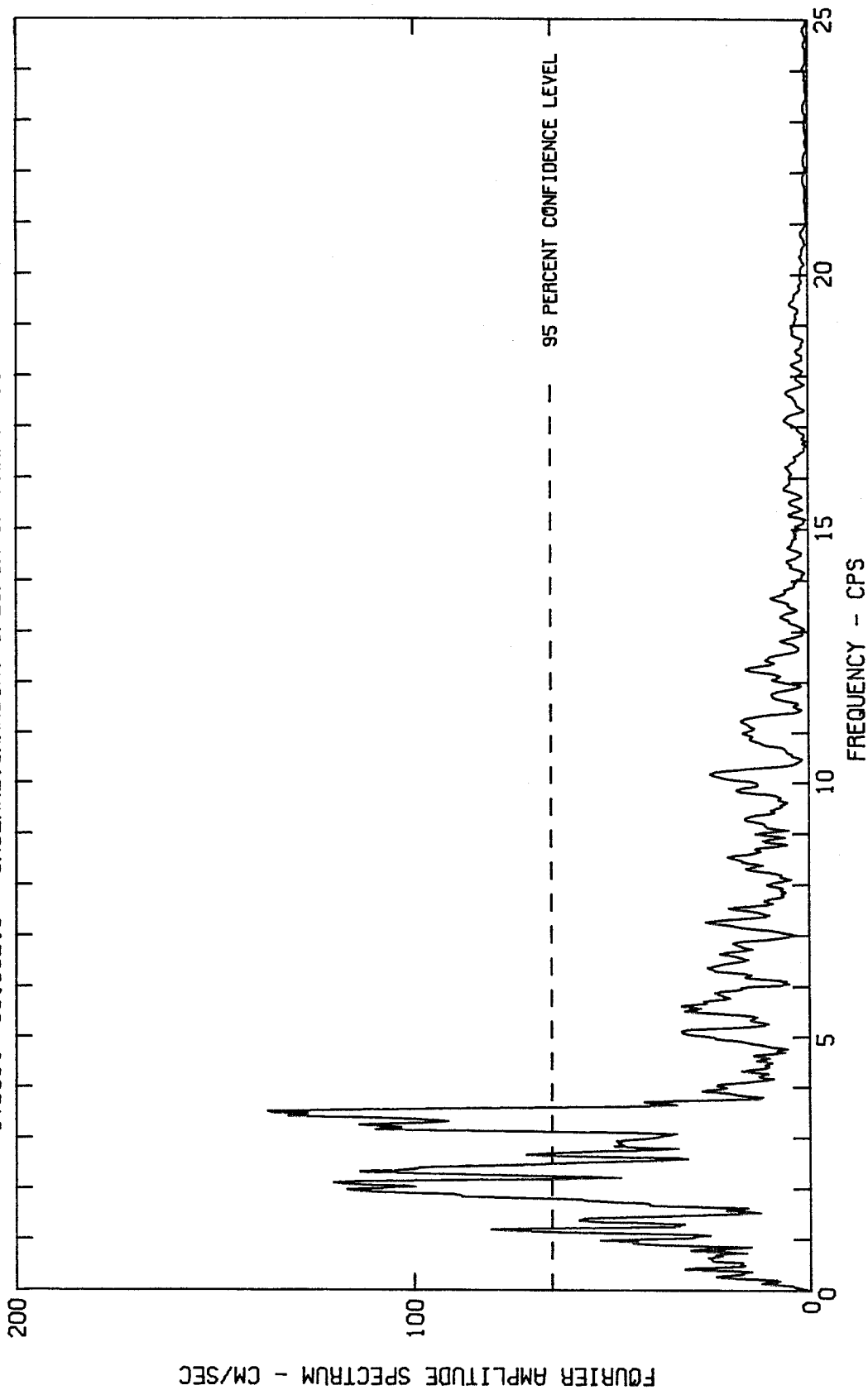
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
PARKFIELD, CALIFORNIA EARTHQUAKE JUNE 27, 1966 - 2026 PST
IV8033 66.001.0 CHOLAME, SHANDON, CALIFORNIA ARRAY NO. 2 COMP DOWN

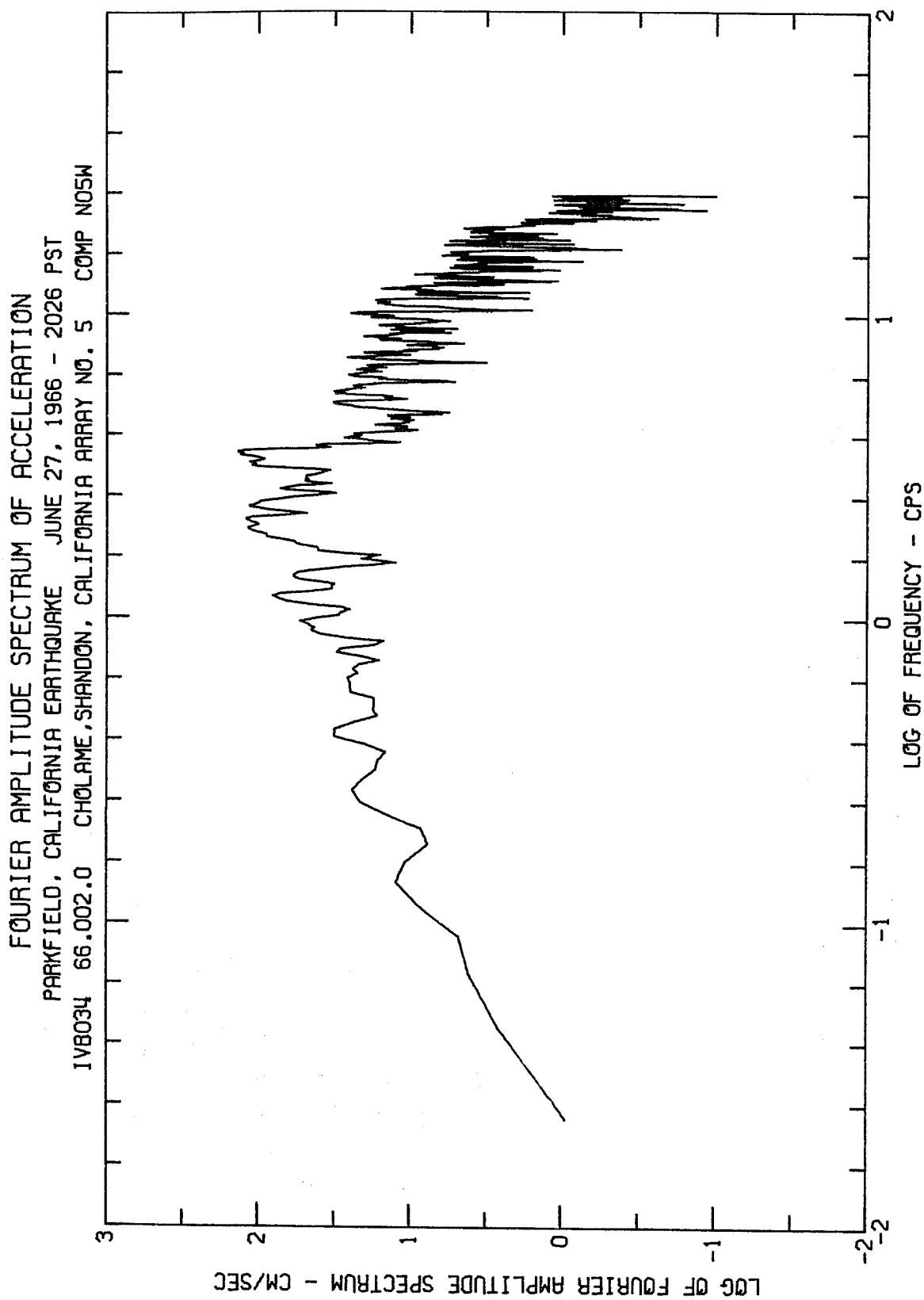


FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
PARKFIELD, CALIFORNIA EARTHQUAKE JUNE 27, 1966 - 2026 PST
1VB033 66.001.0 CHOLAME, SHANDON, CALIFORNIA ARRAY NO. 2 COMP DOWN

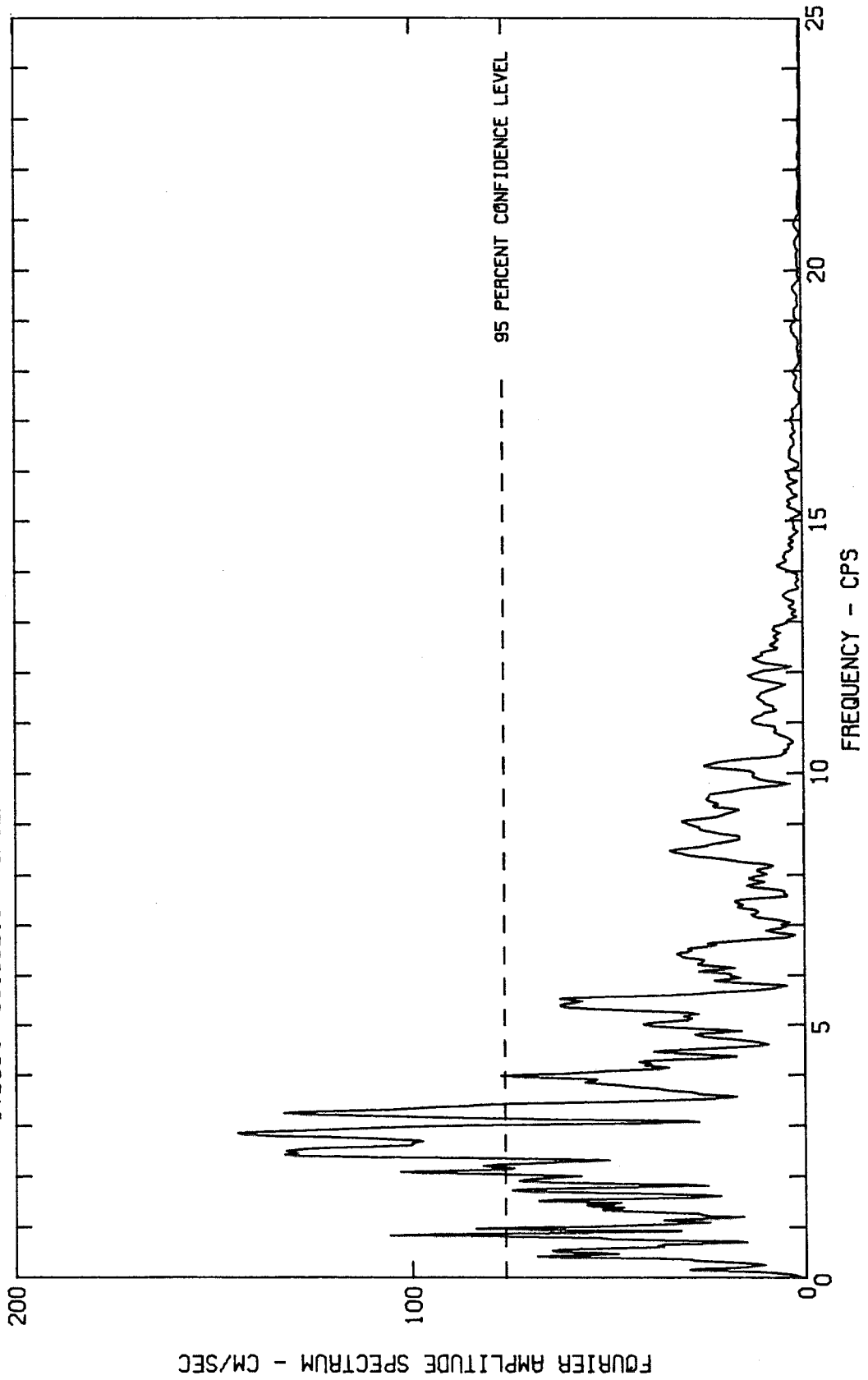


FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
PARKFIELD, CALIFORNIA EARTHQUAKE JUNE 27, 1966 - 2026 PST
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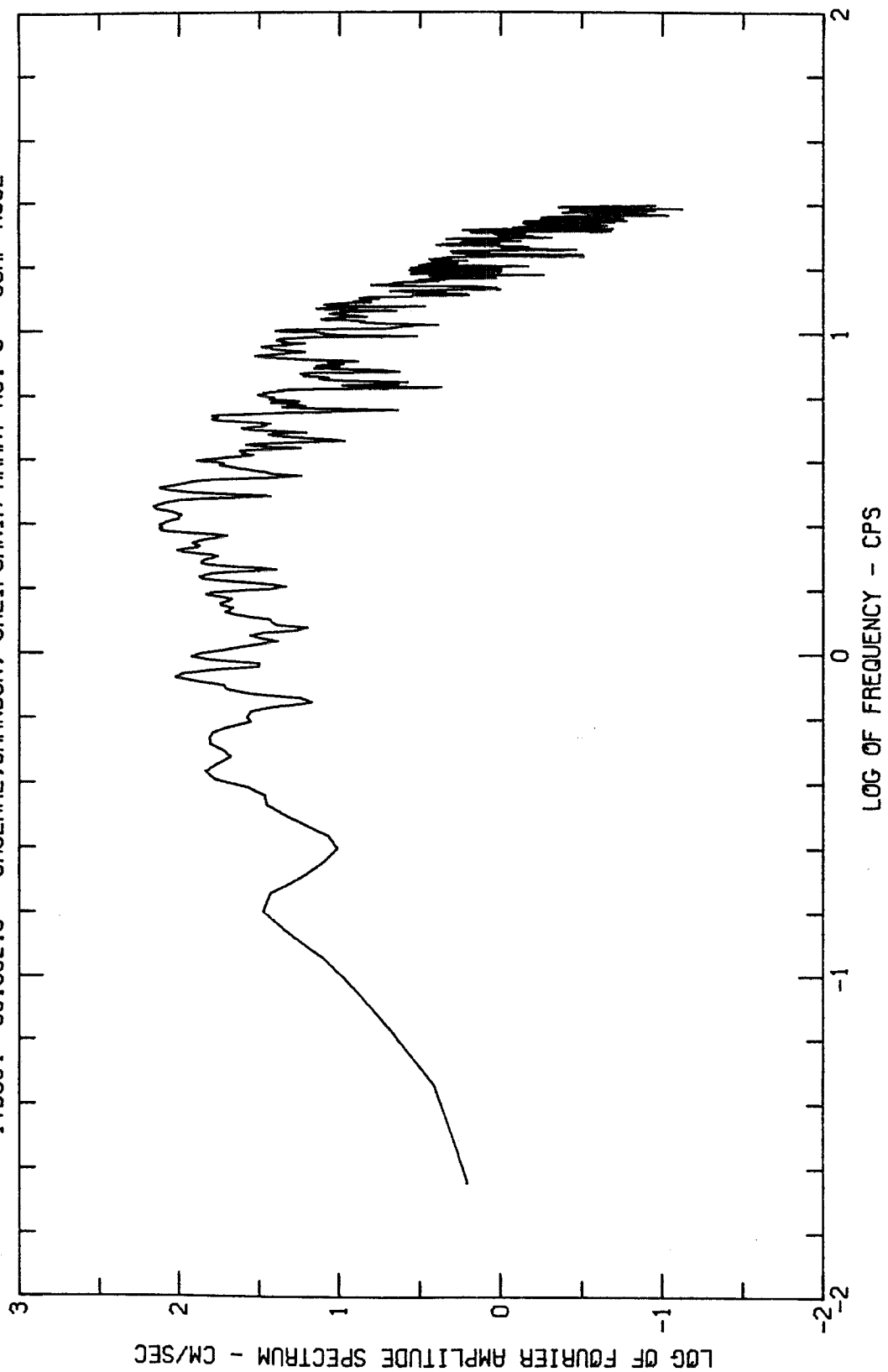




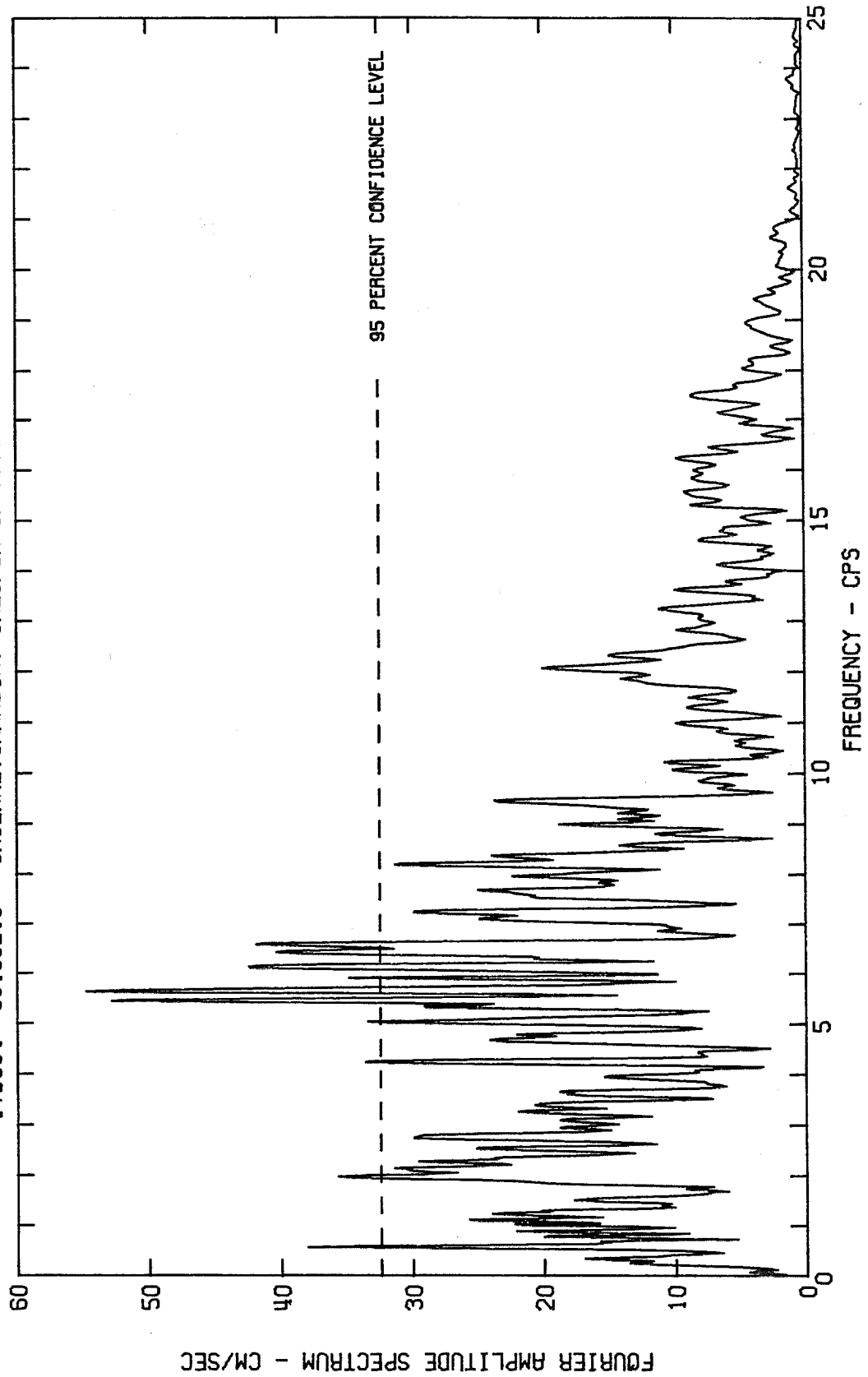
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1V8034 66.002.0 CHOLAME, SHANDON, CALIFORNIA ARRAY NO. 5 COMP N85E



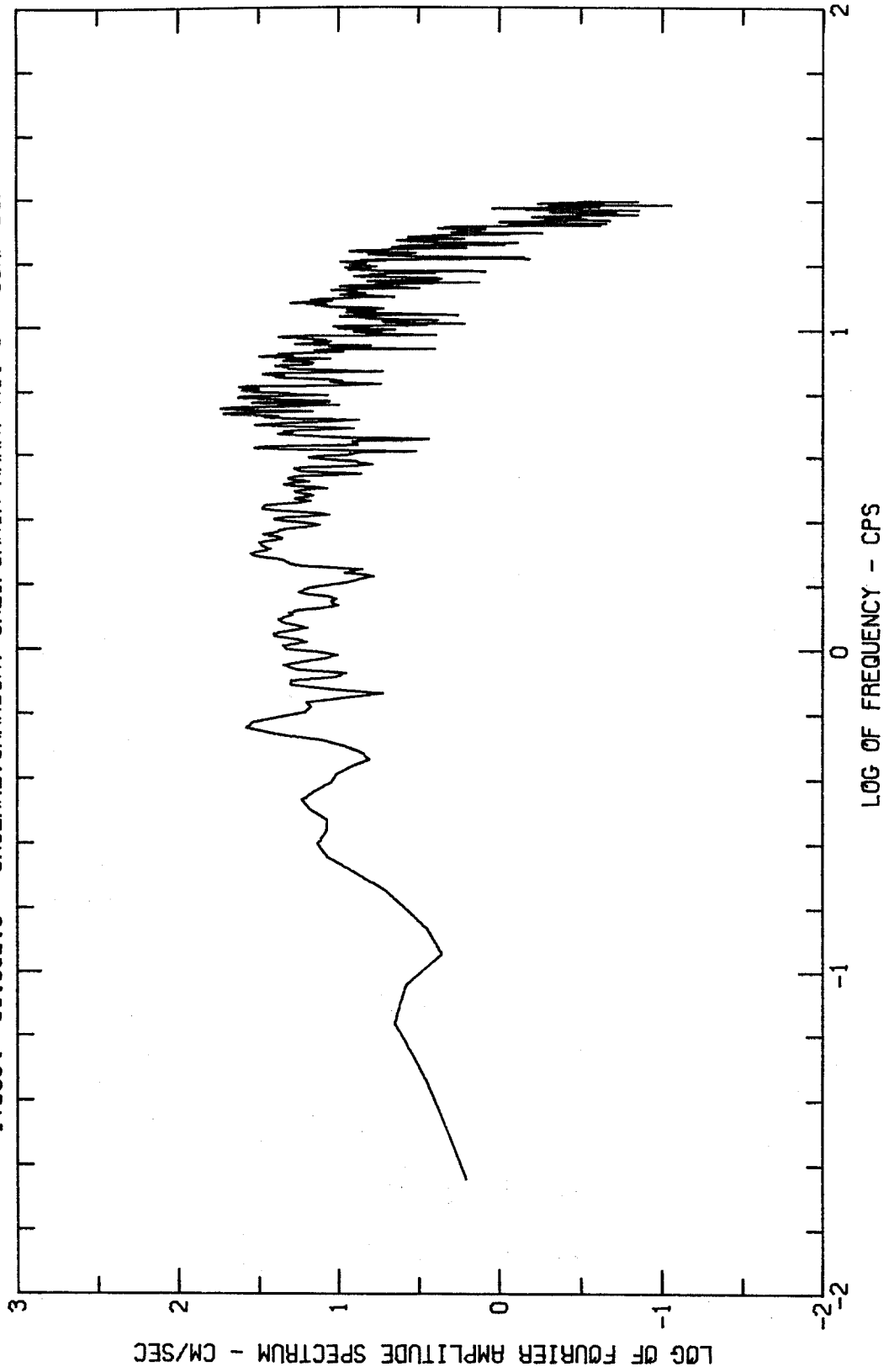
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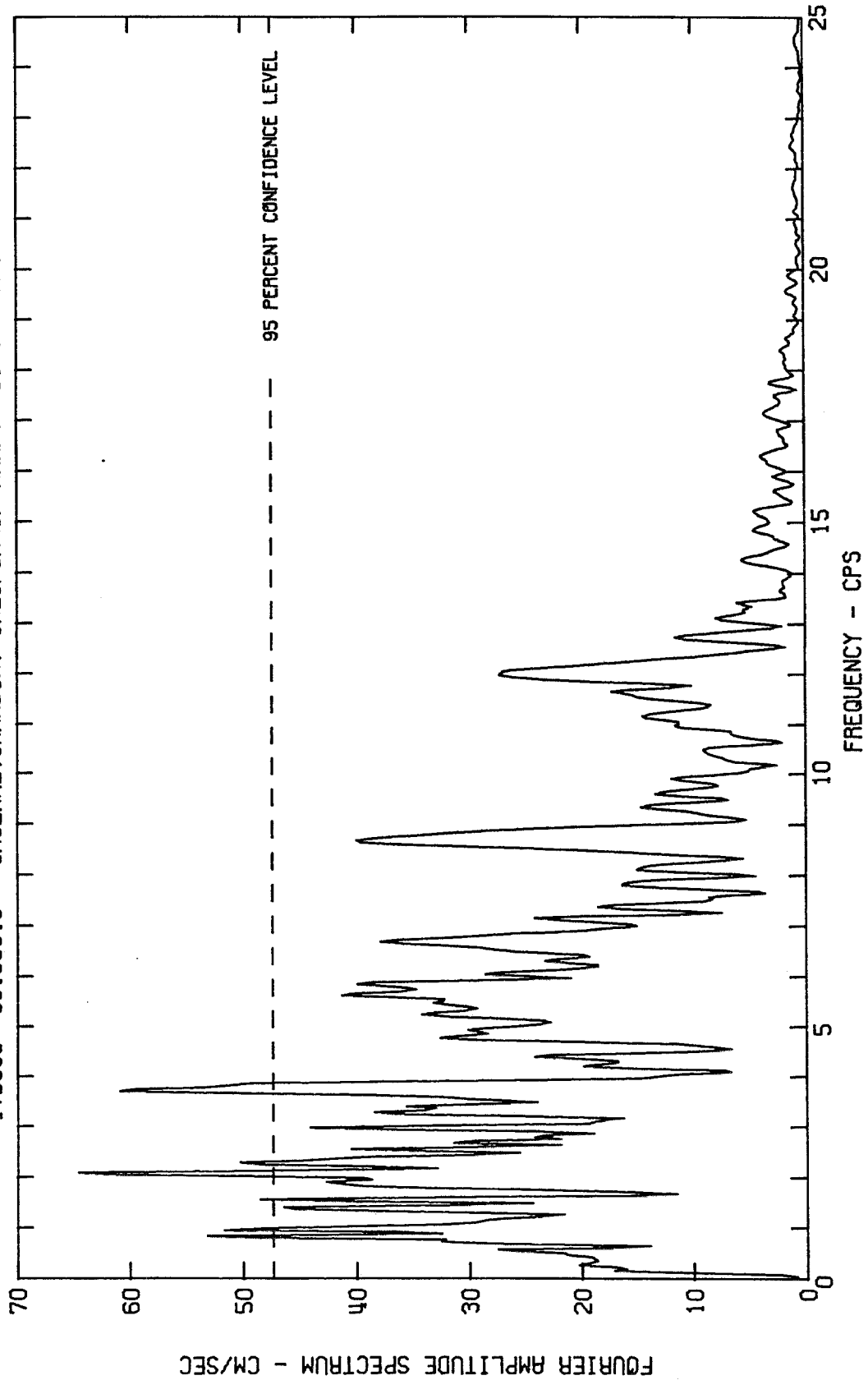
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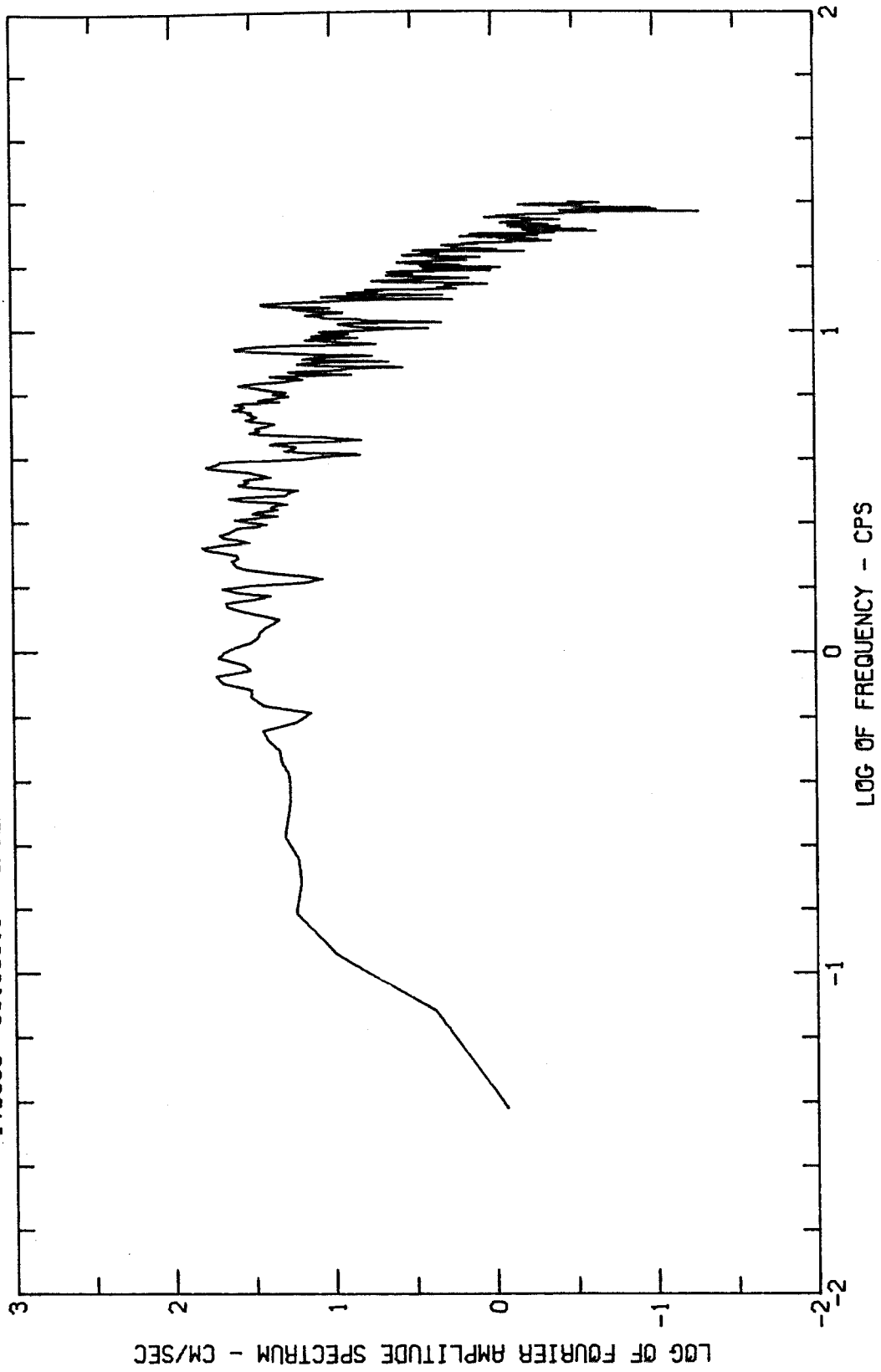
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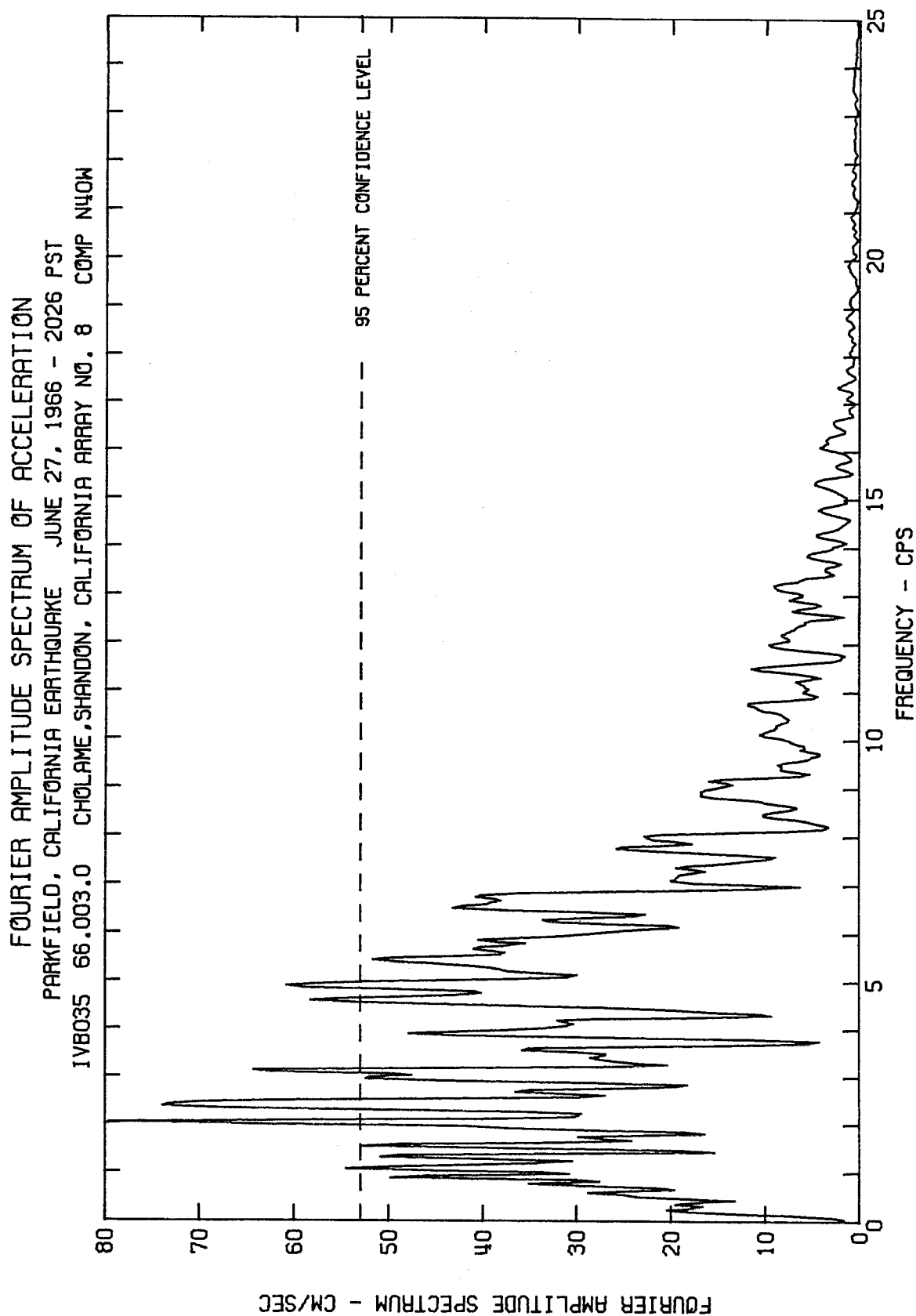


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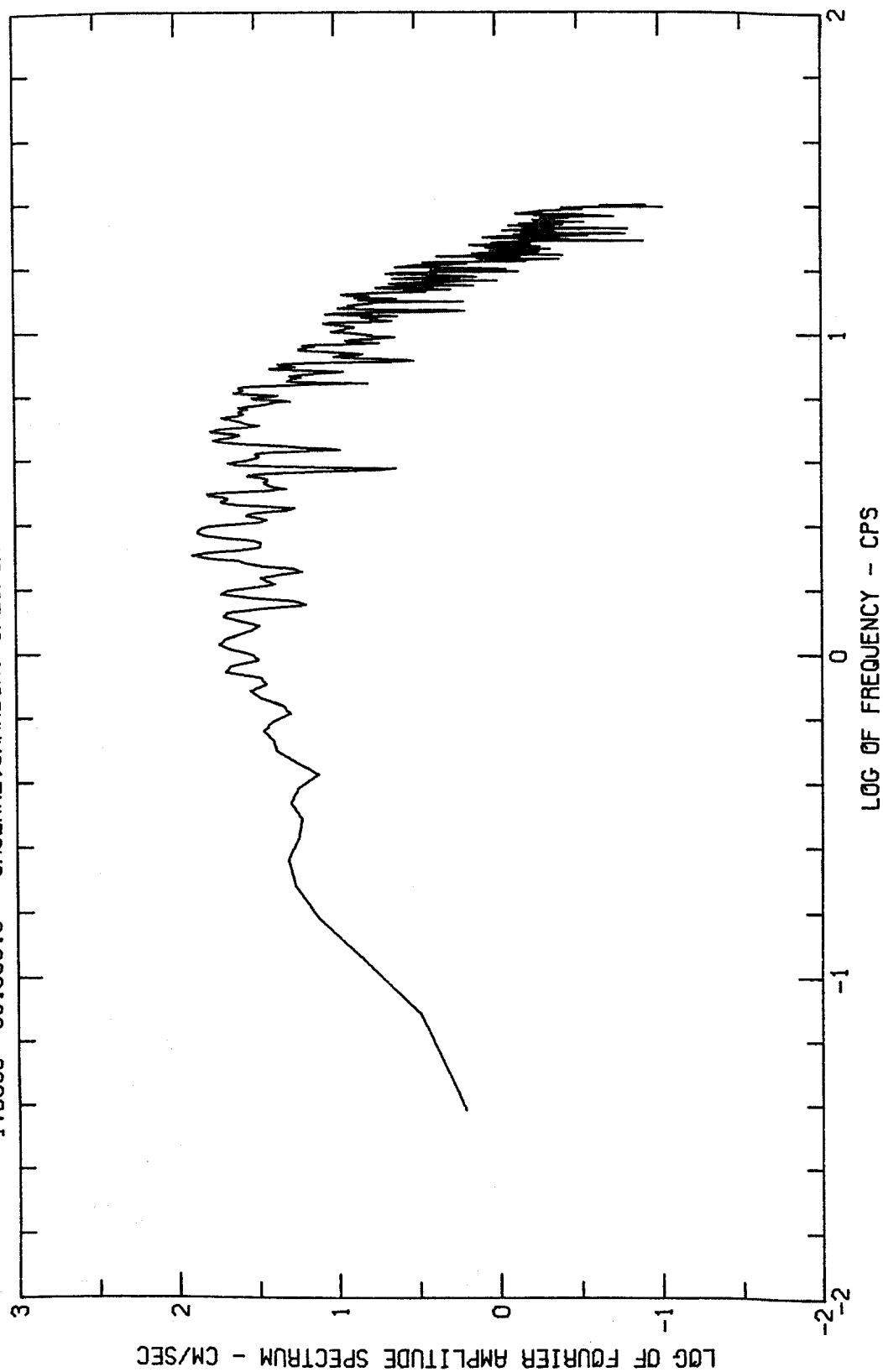


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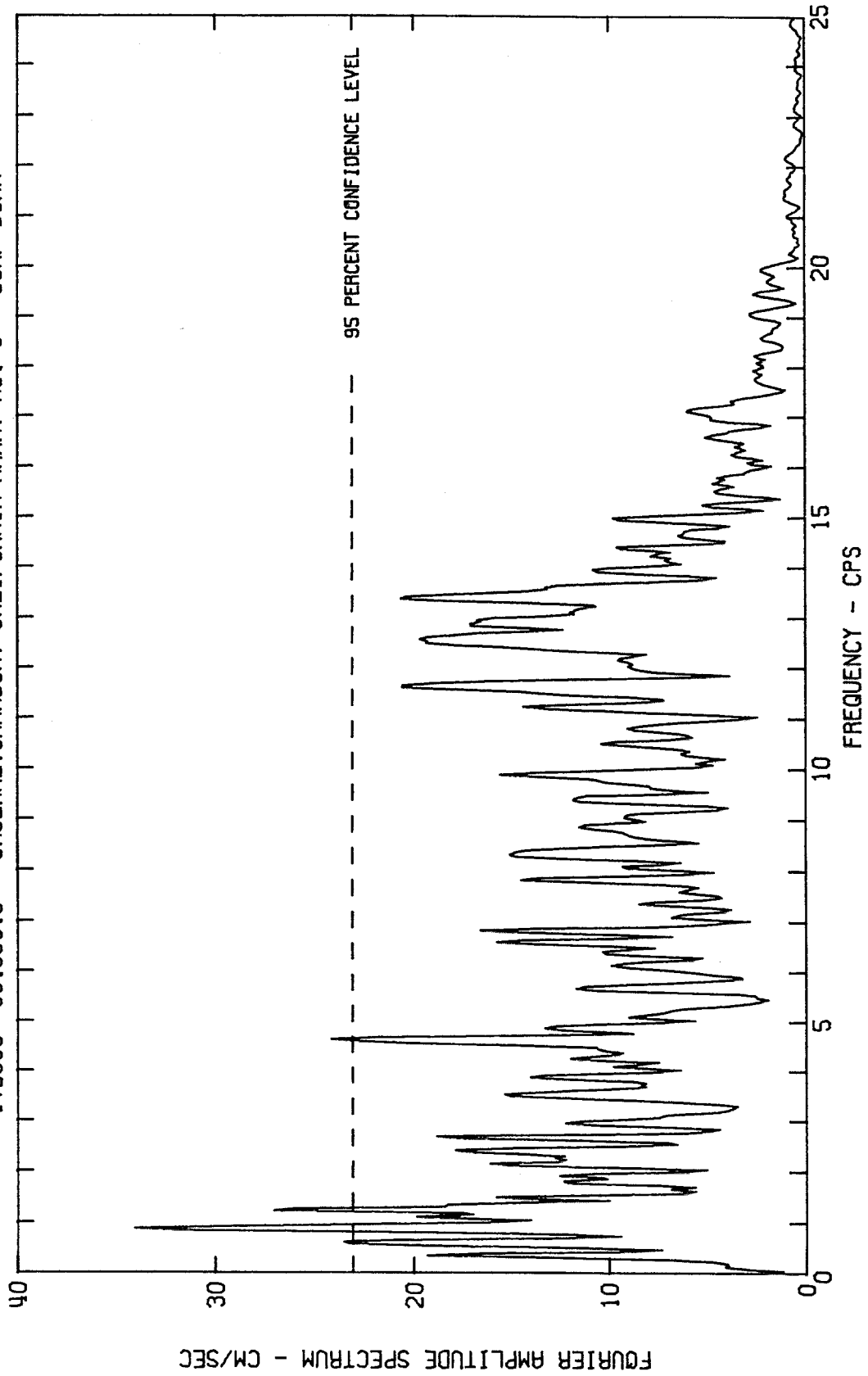




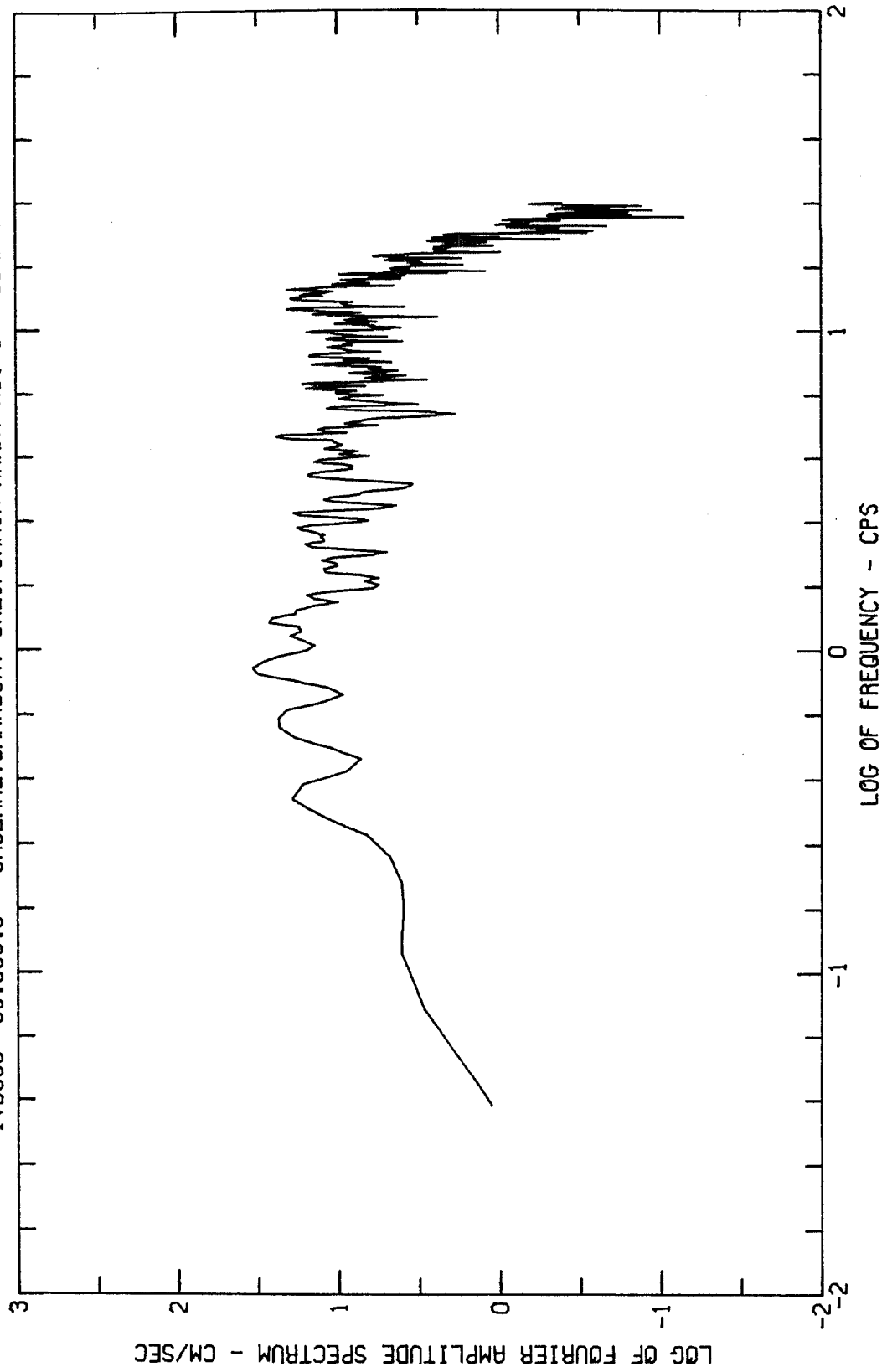
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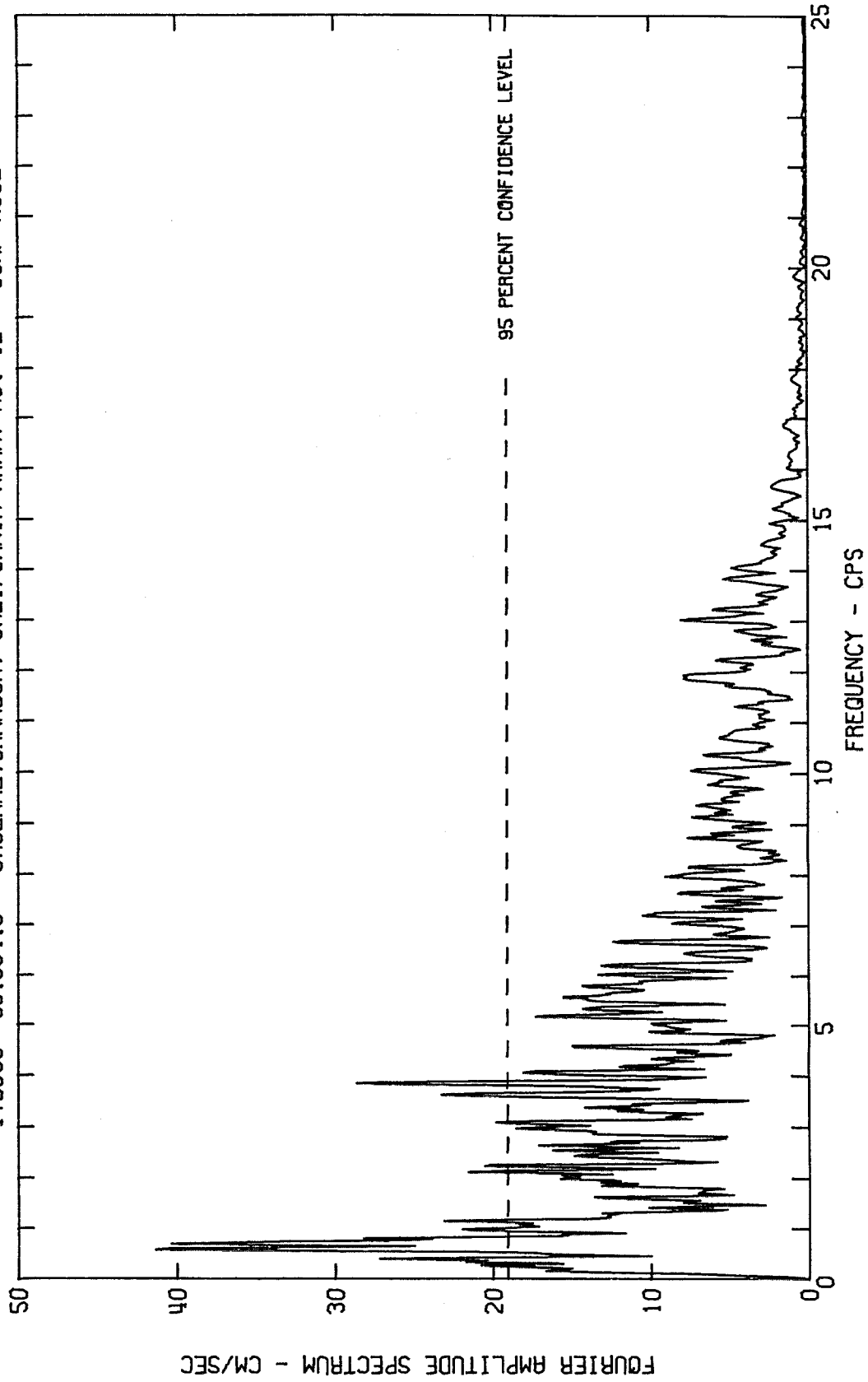
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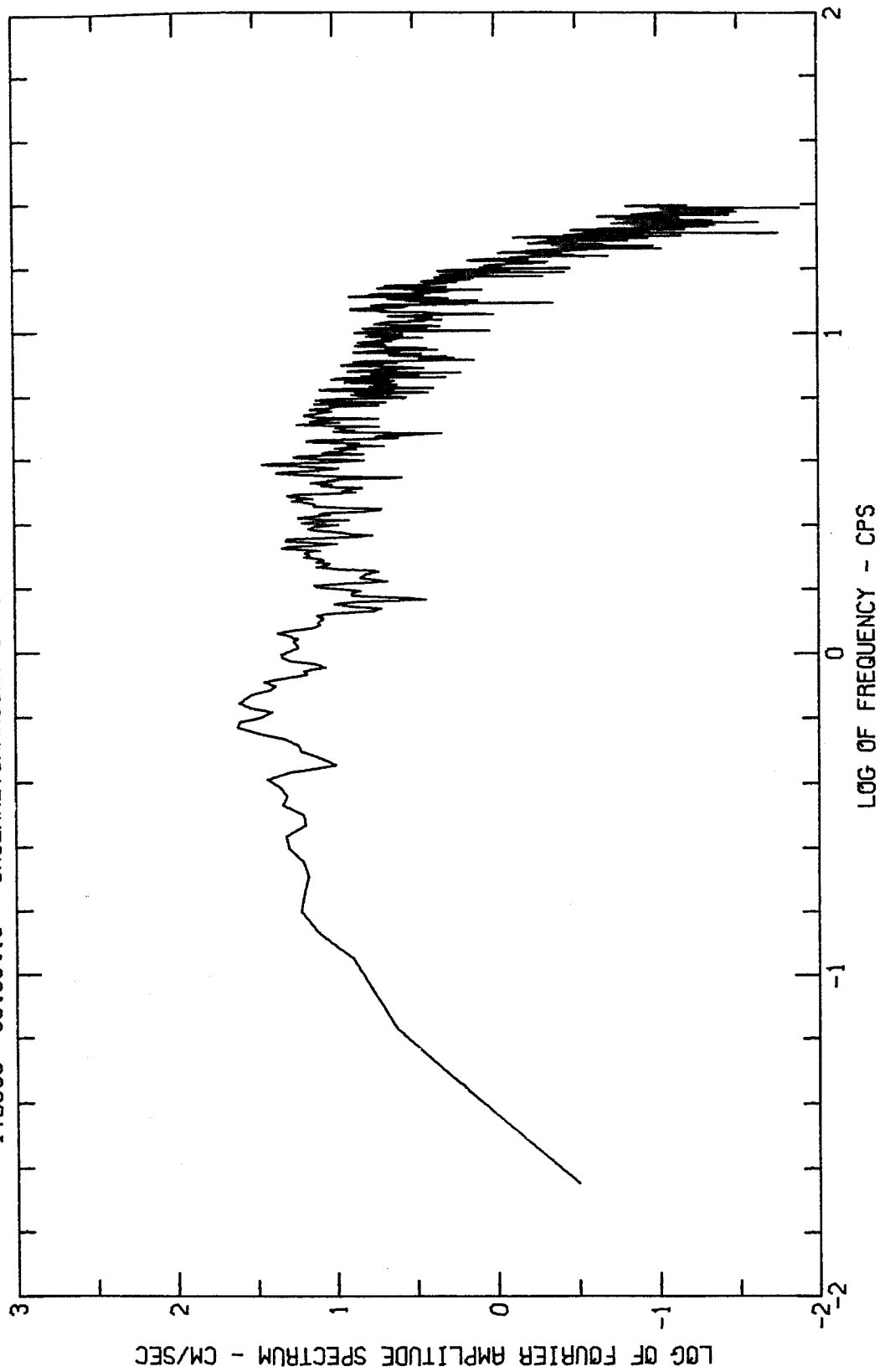
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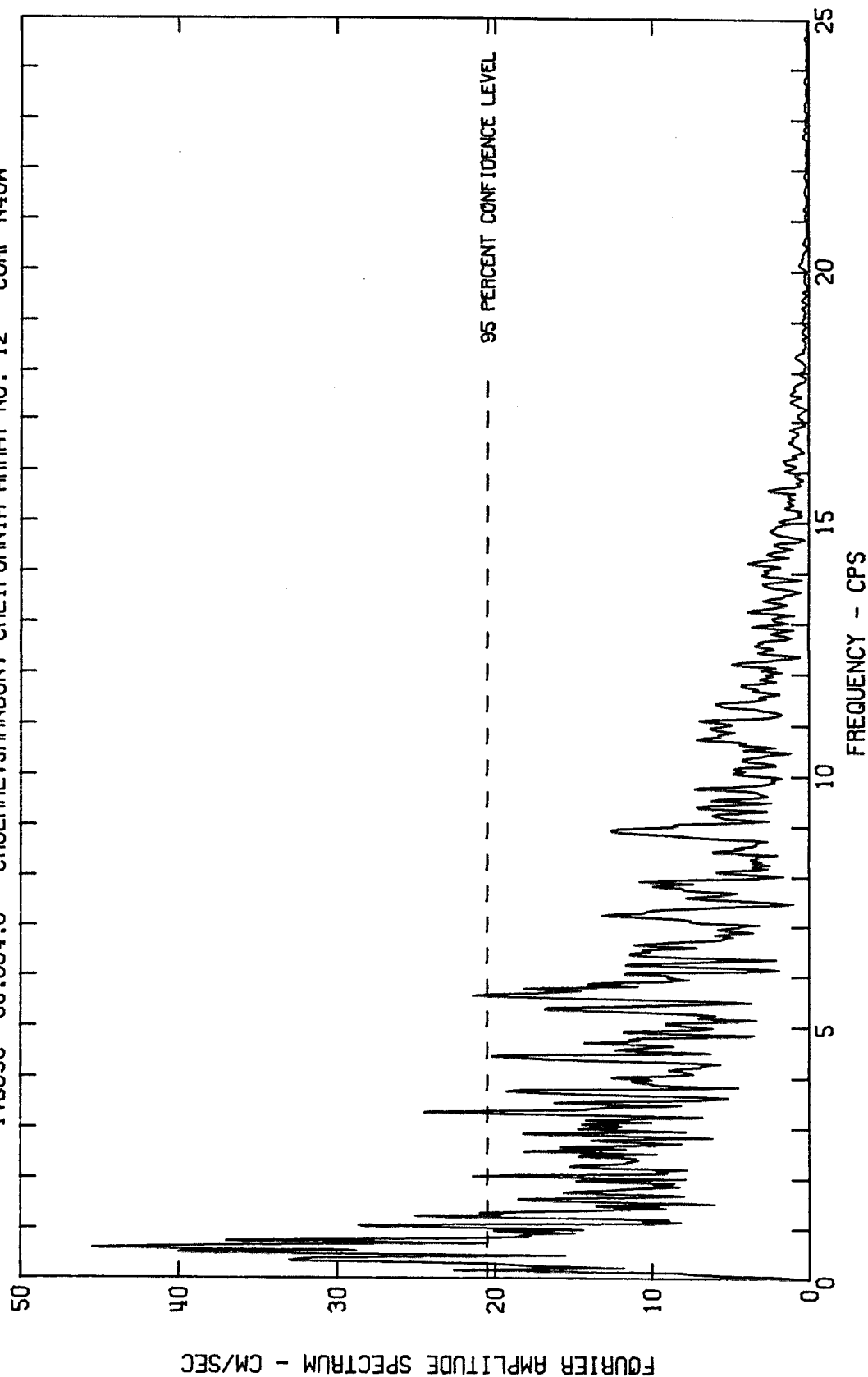
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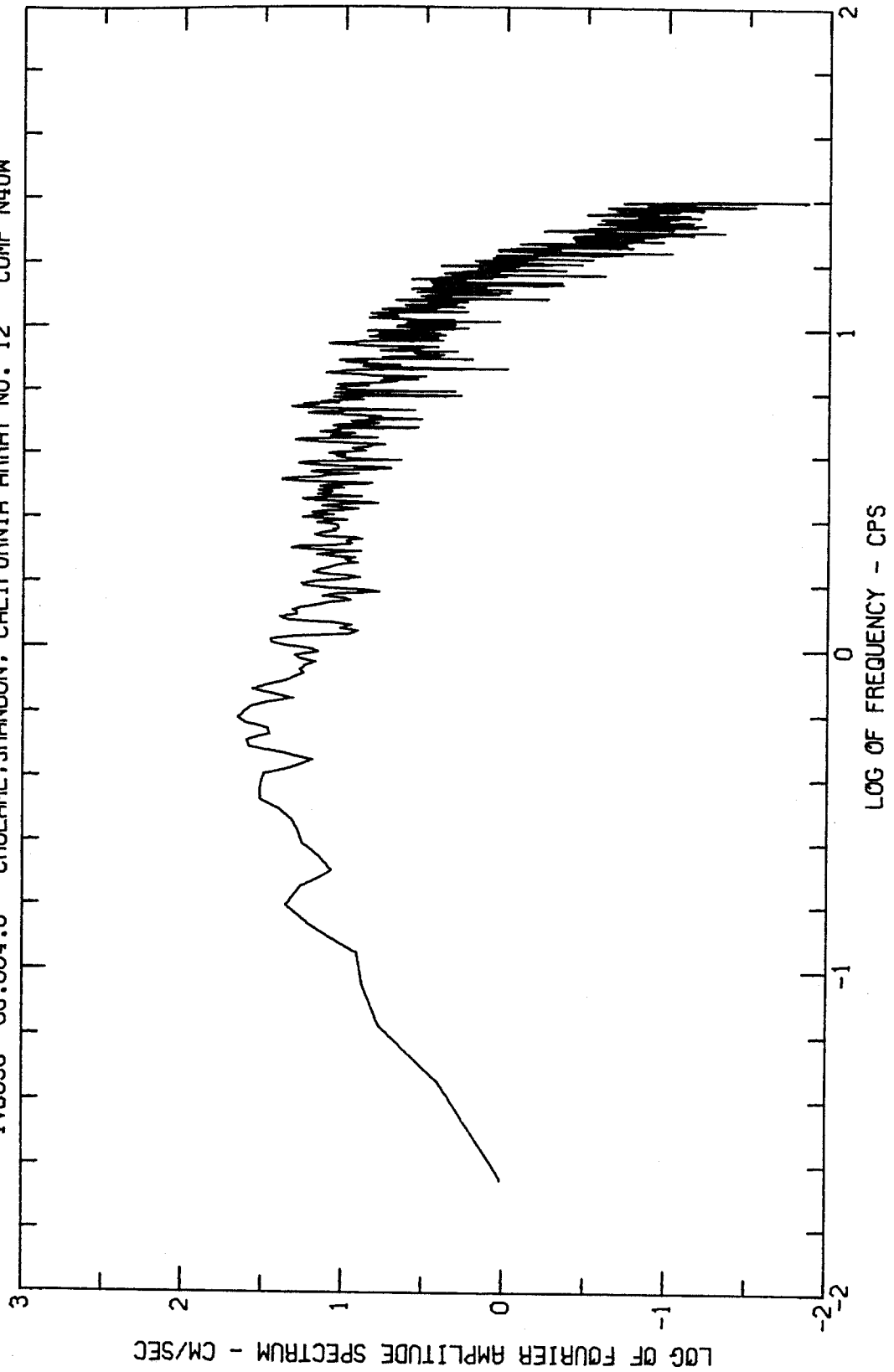
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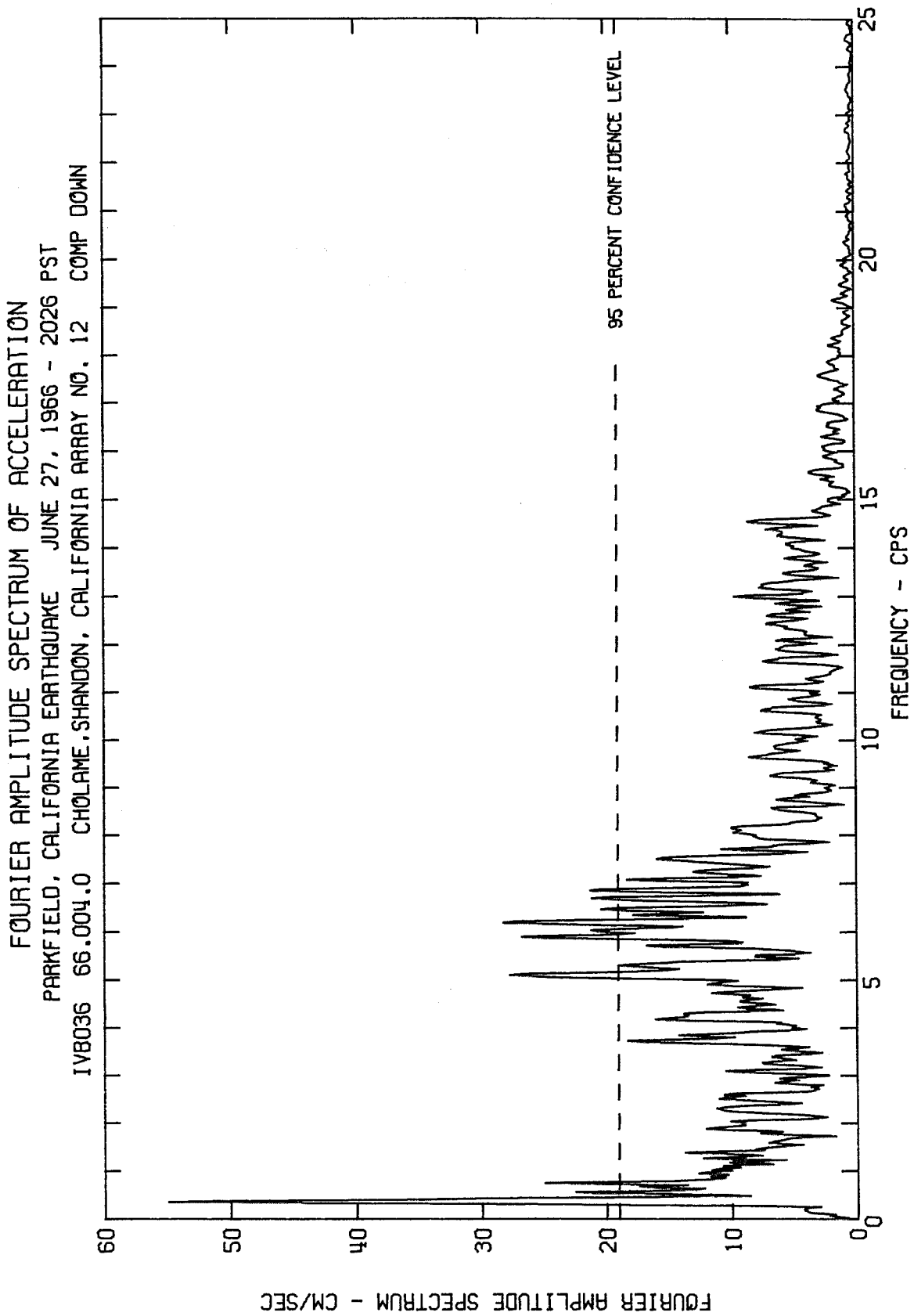


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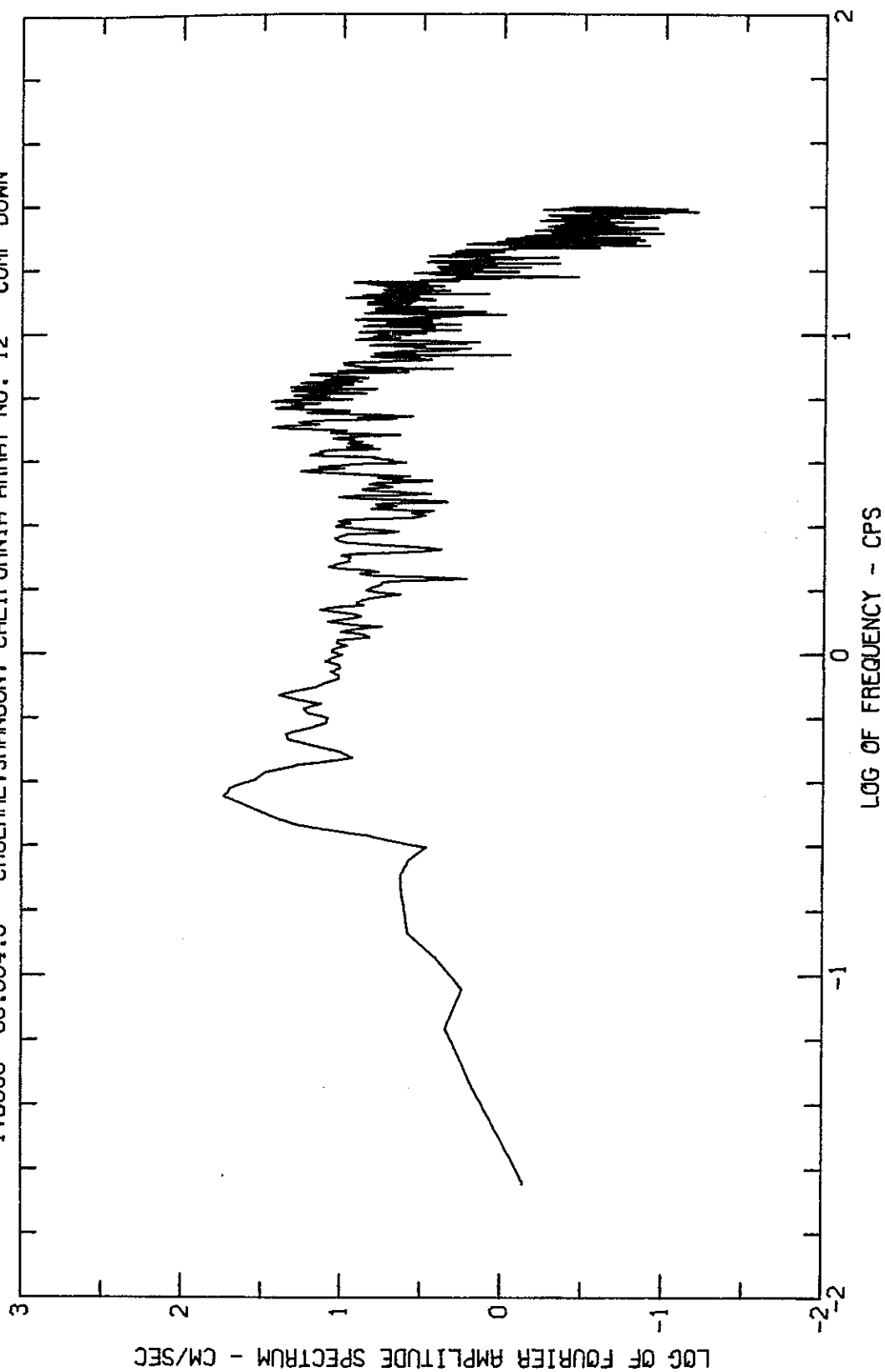


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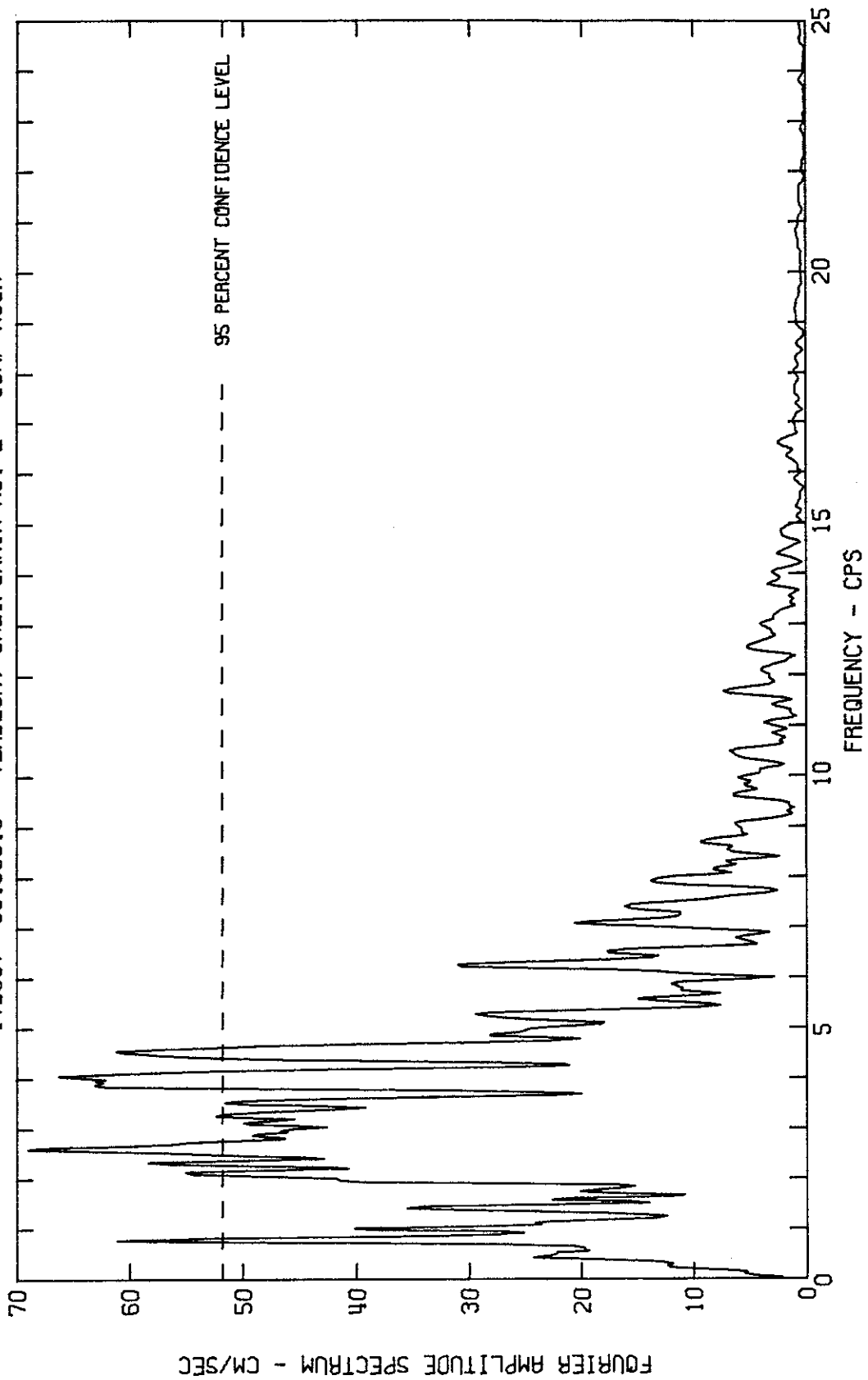




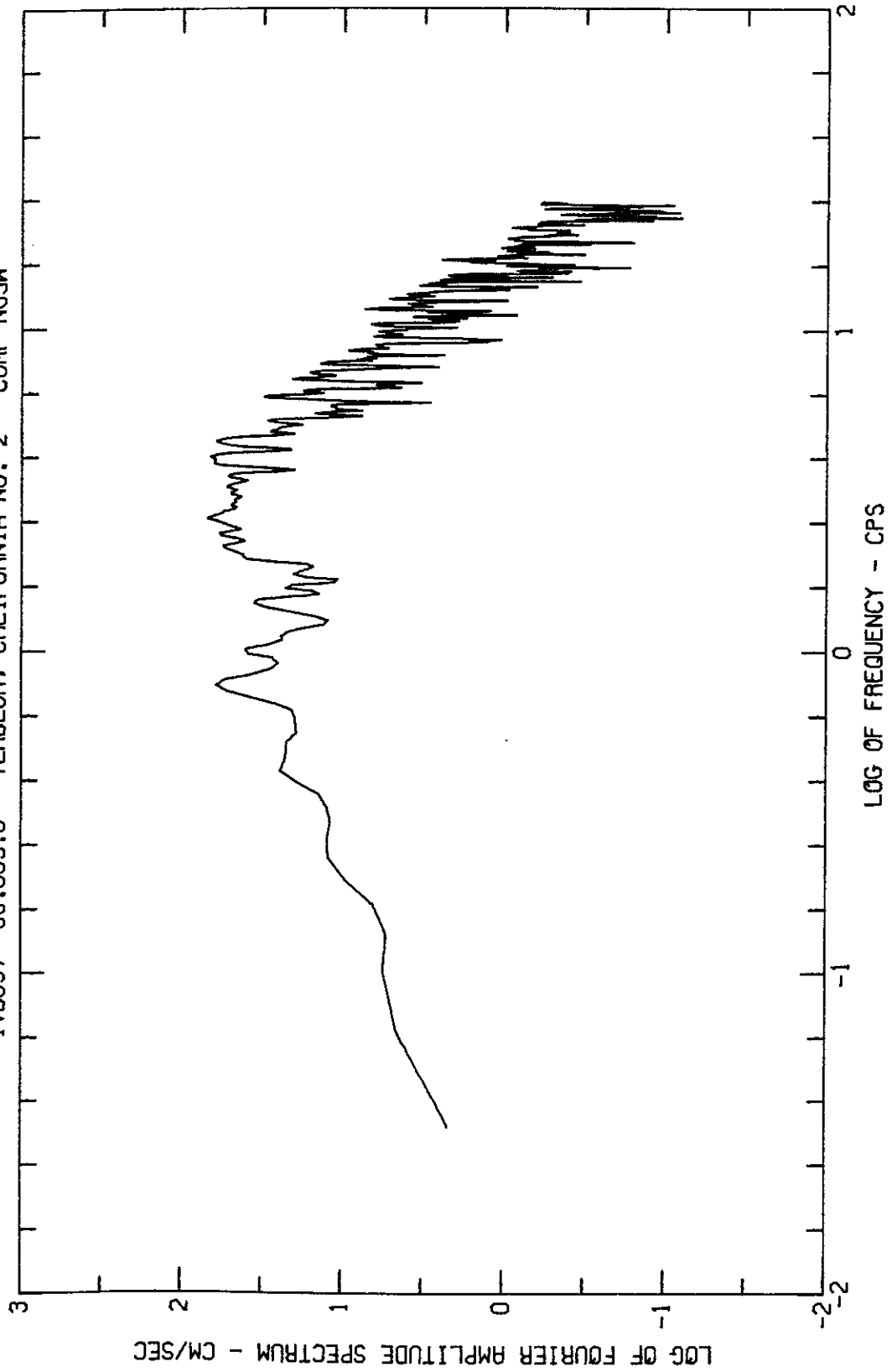
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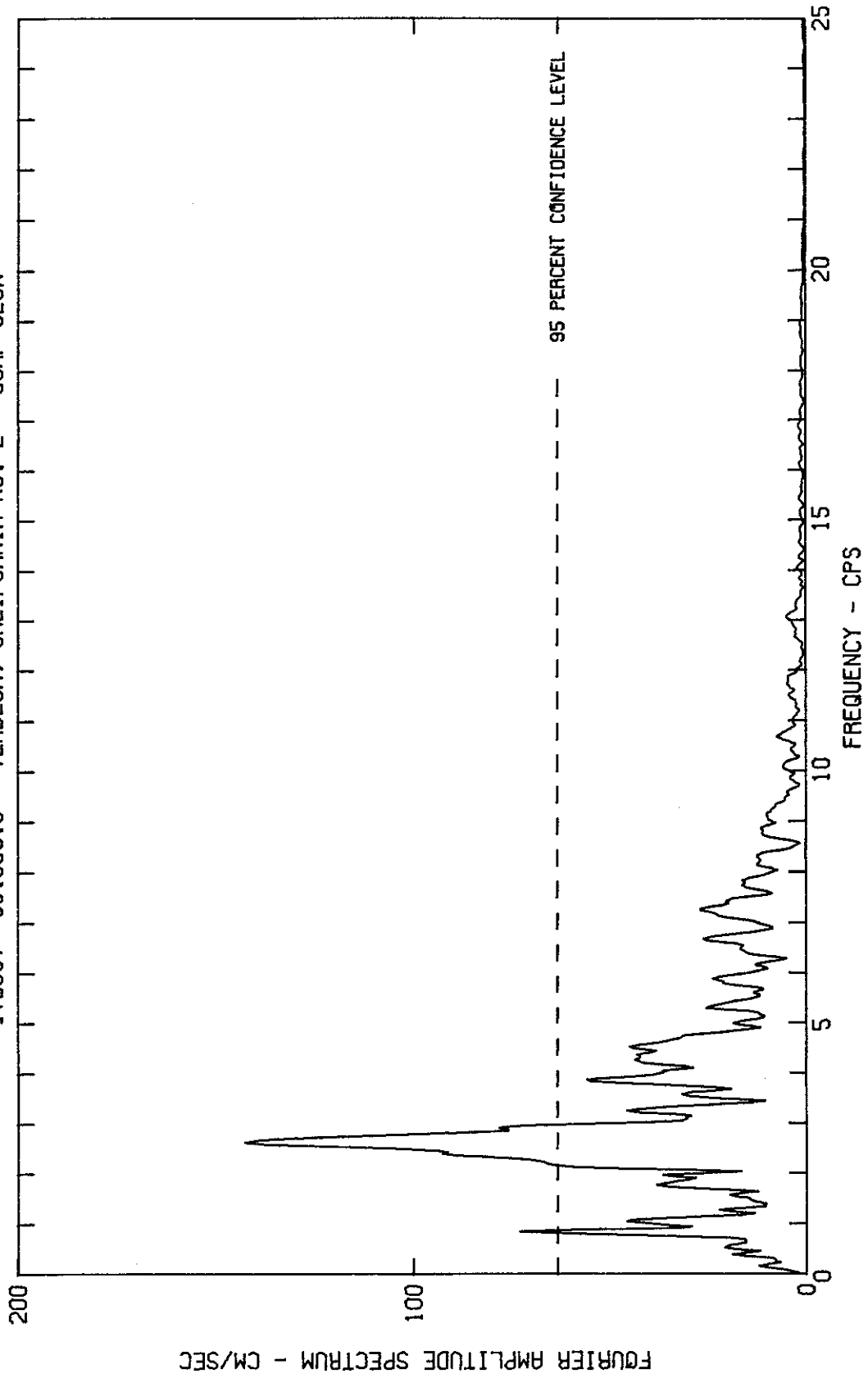
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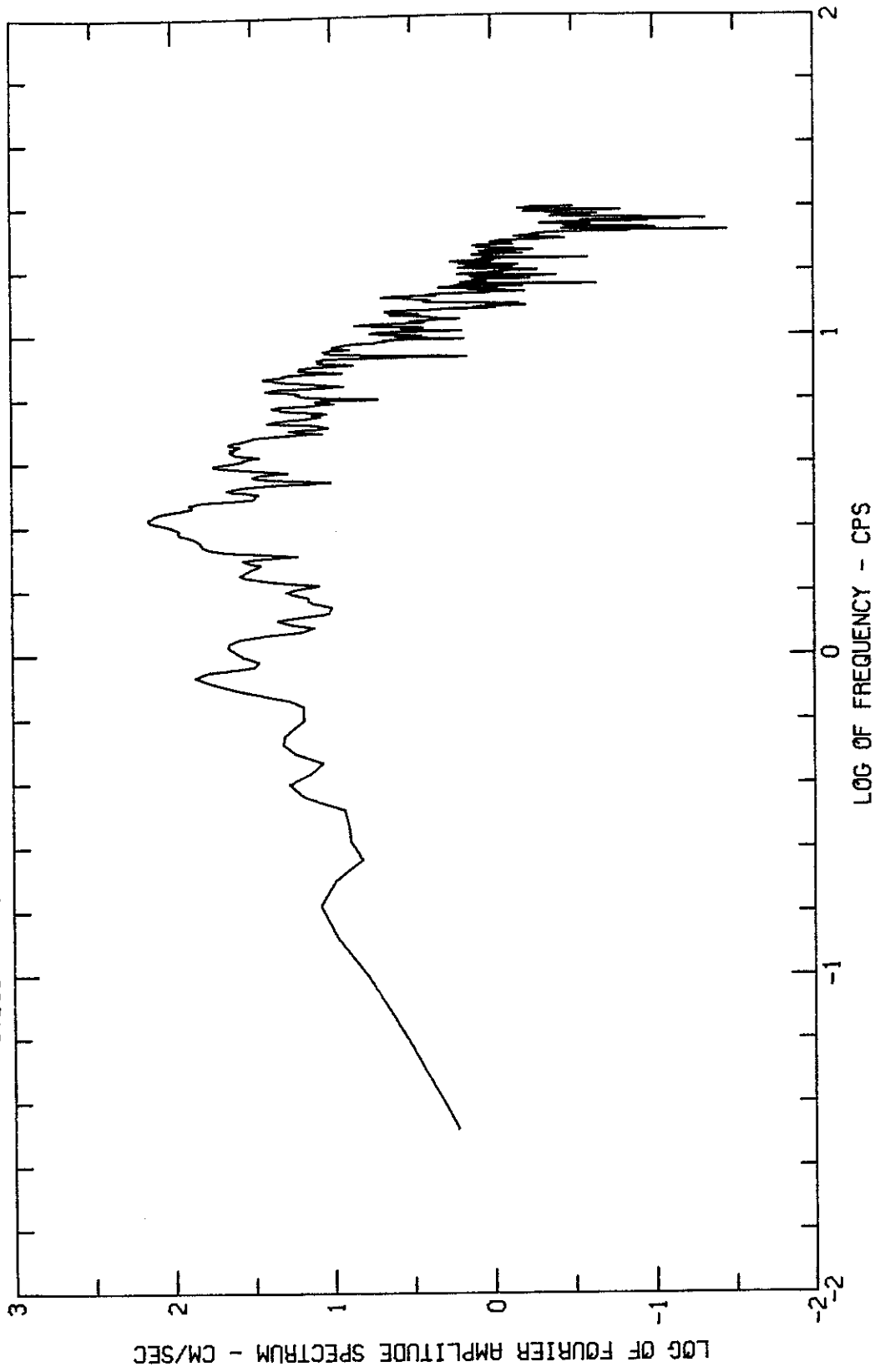
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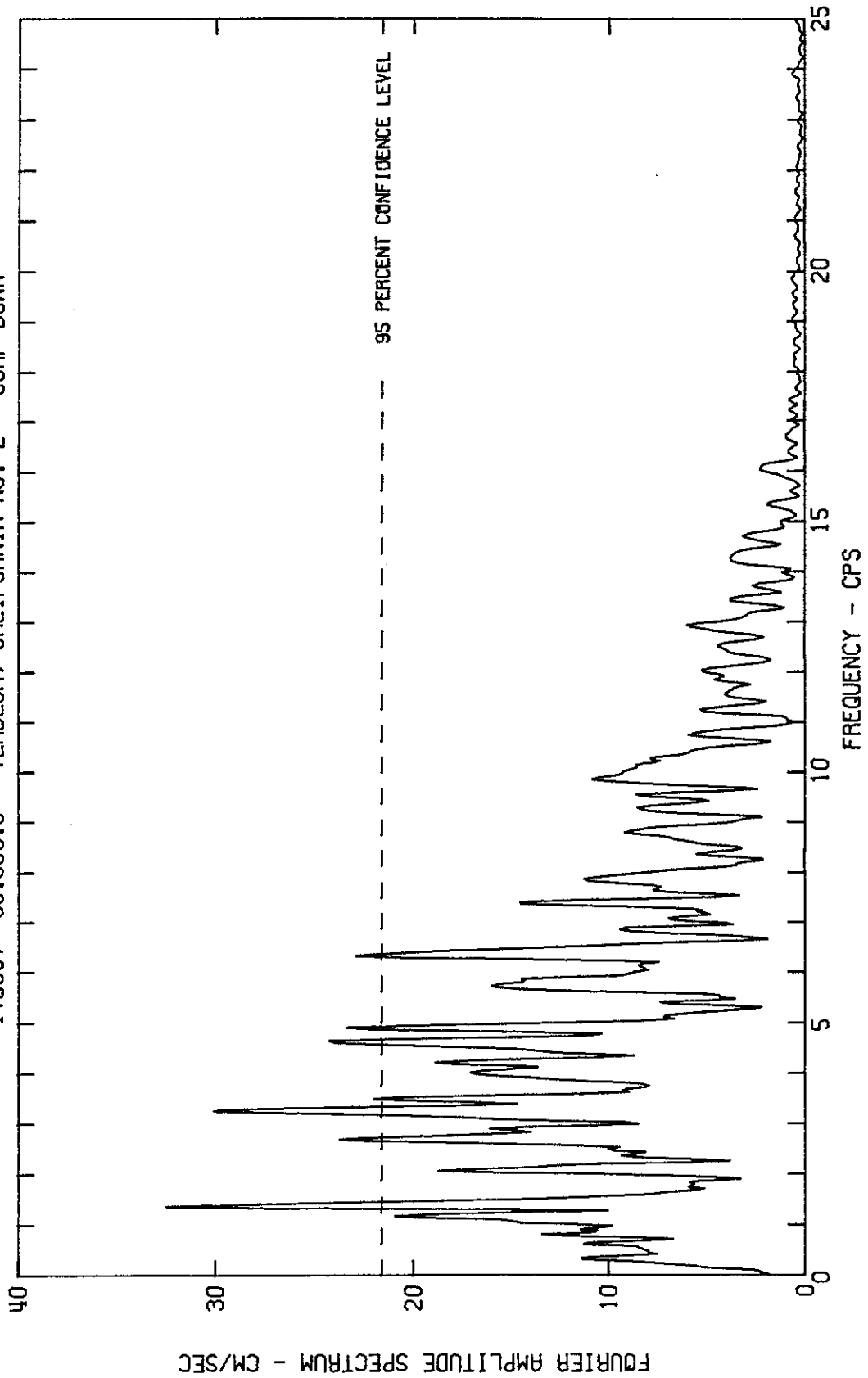
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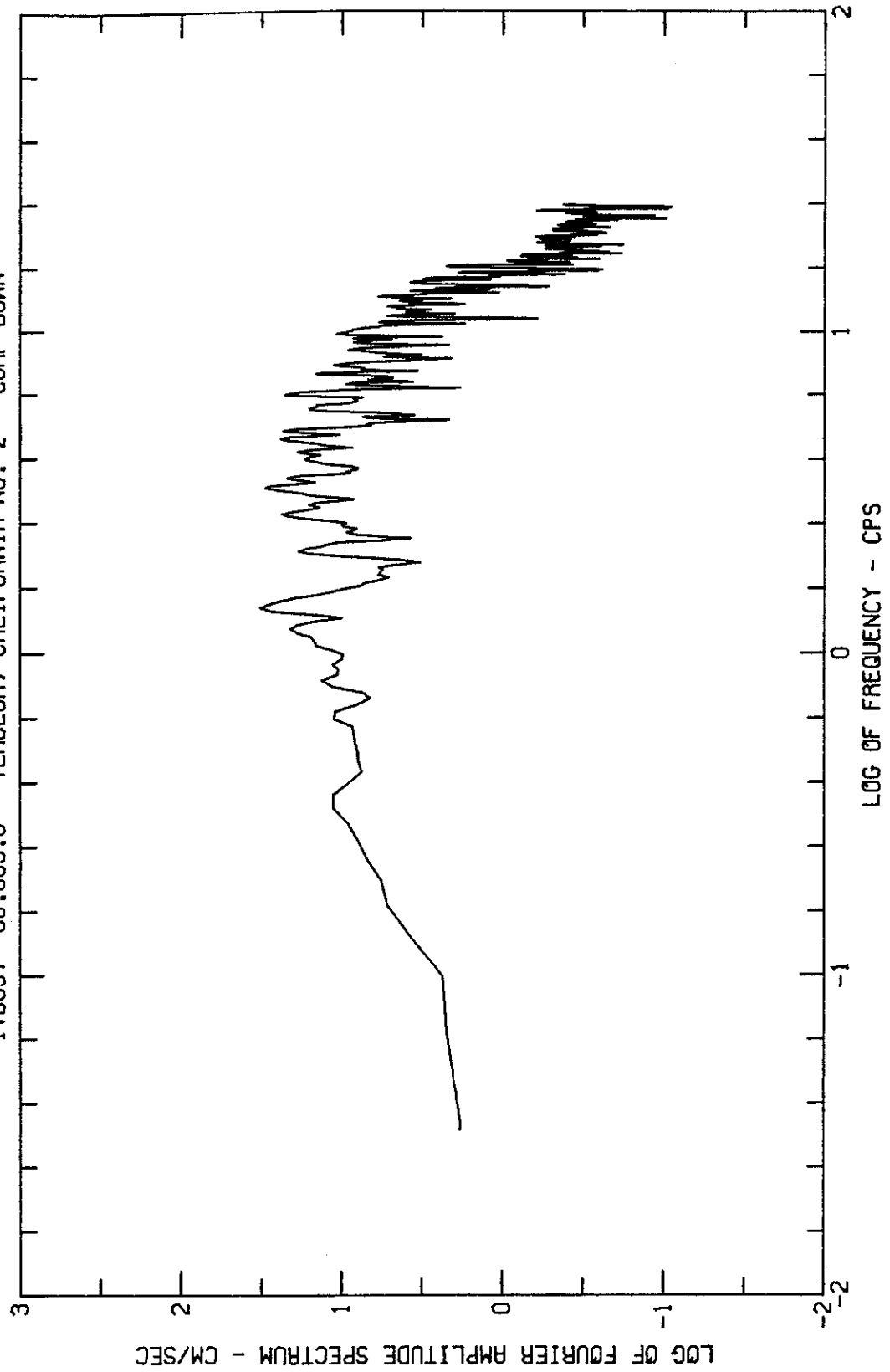
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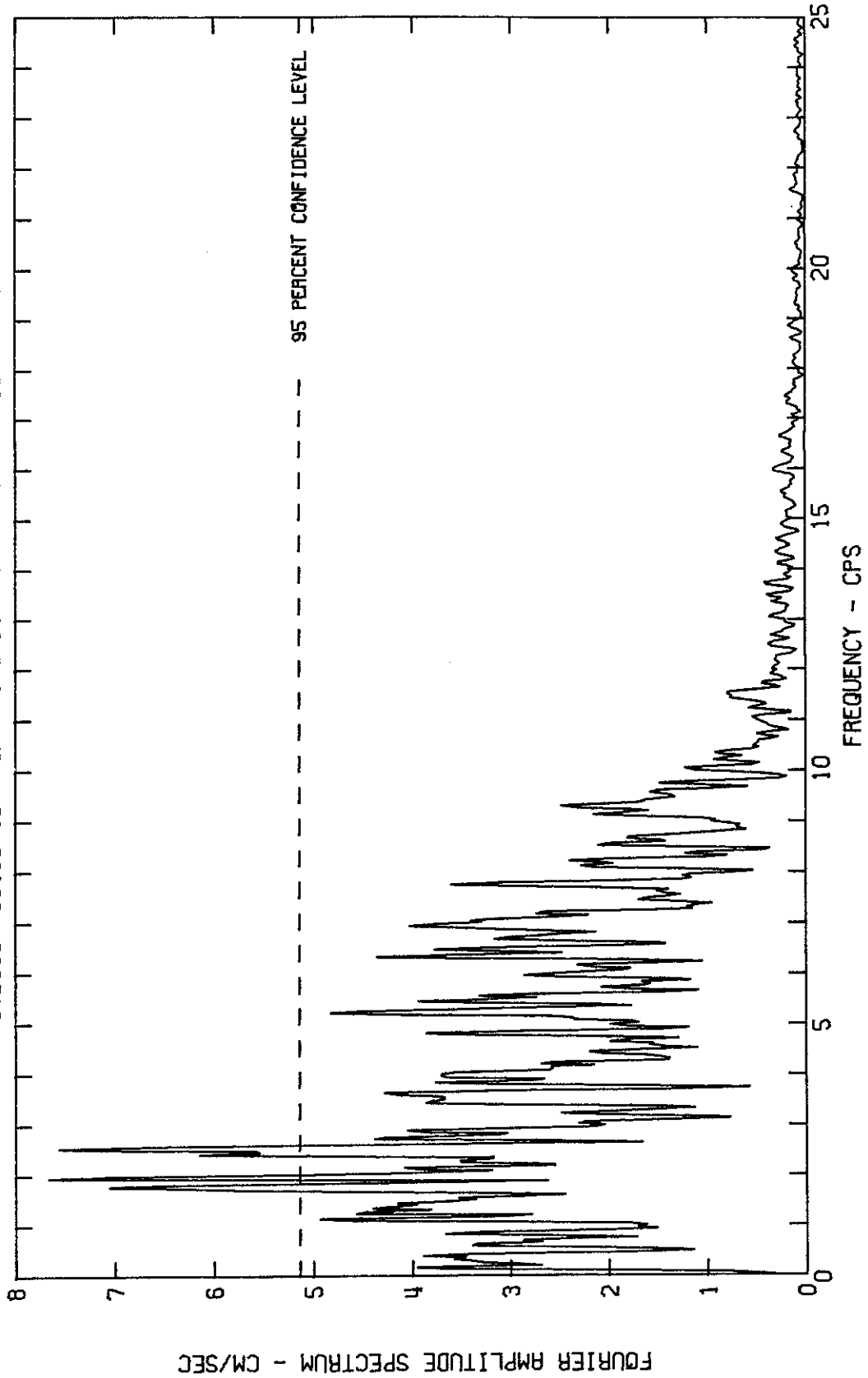
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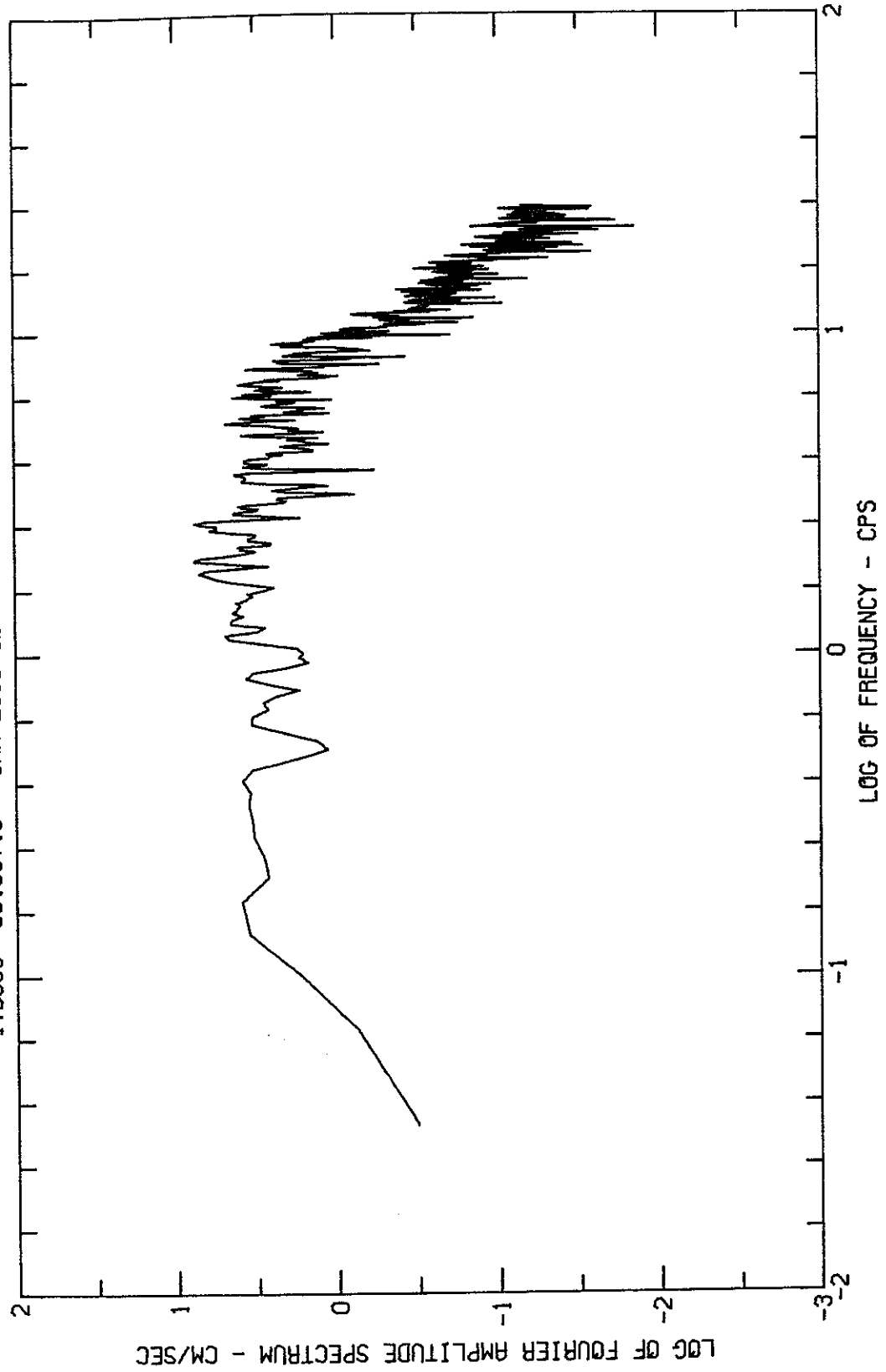
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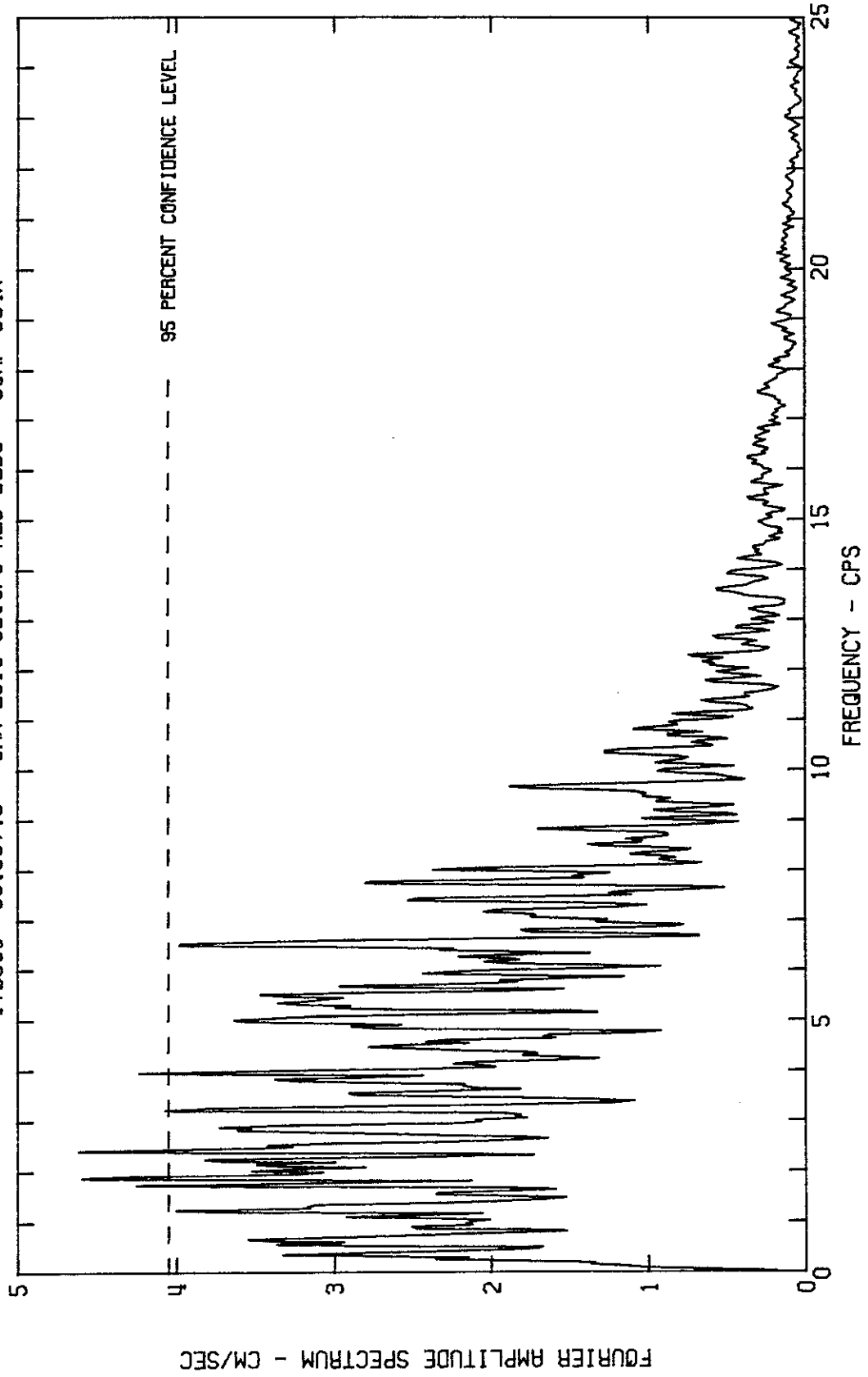
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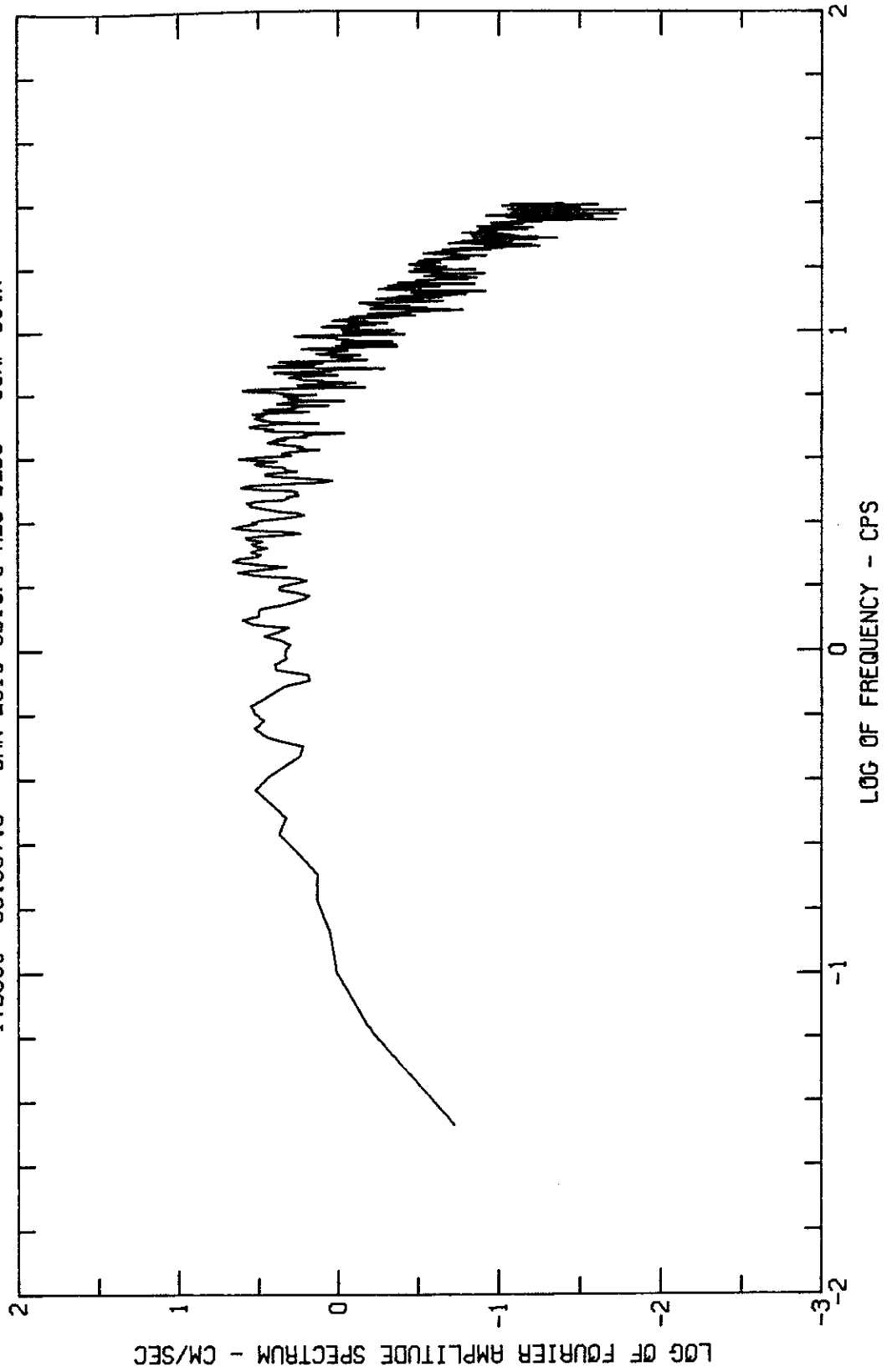
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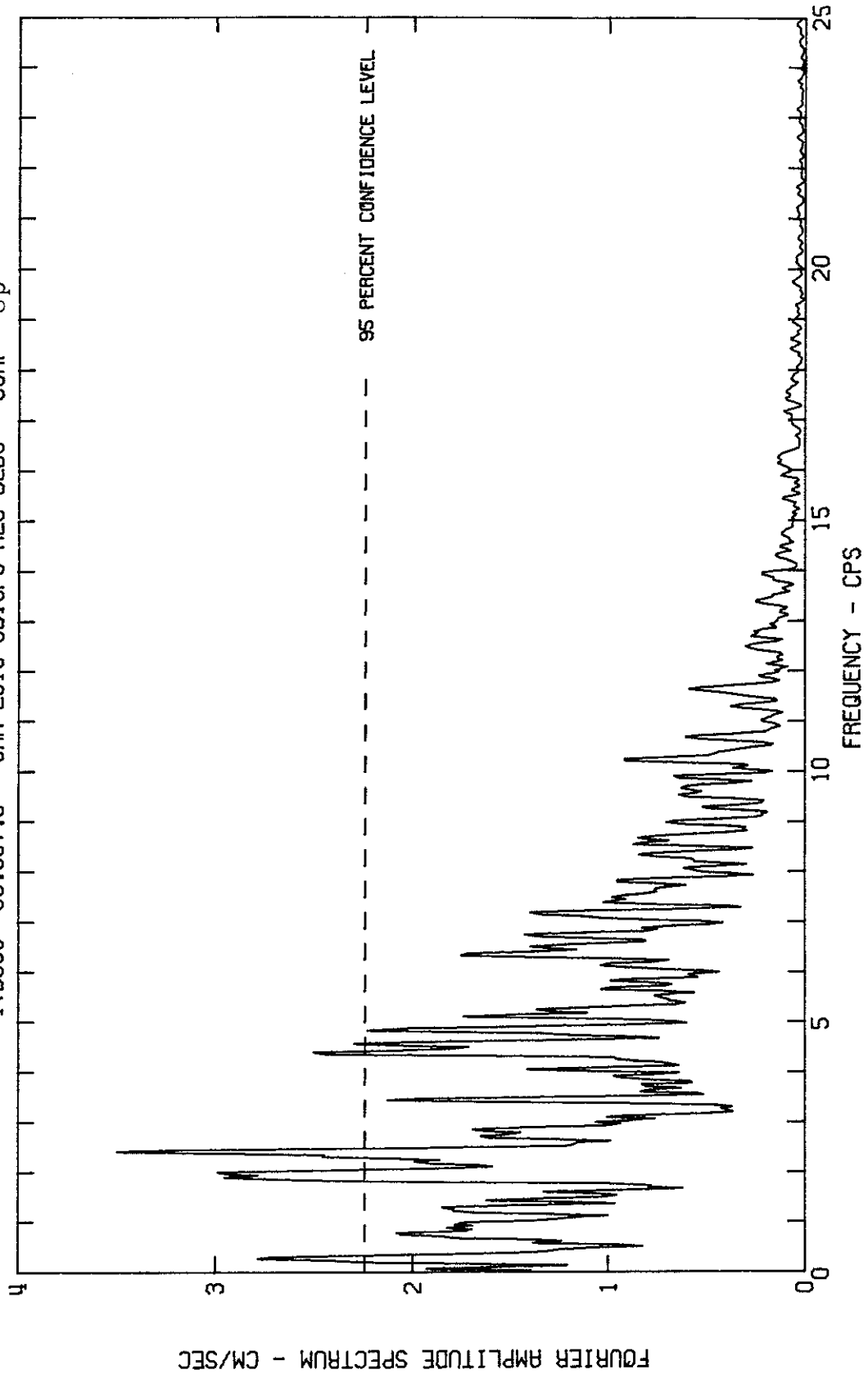
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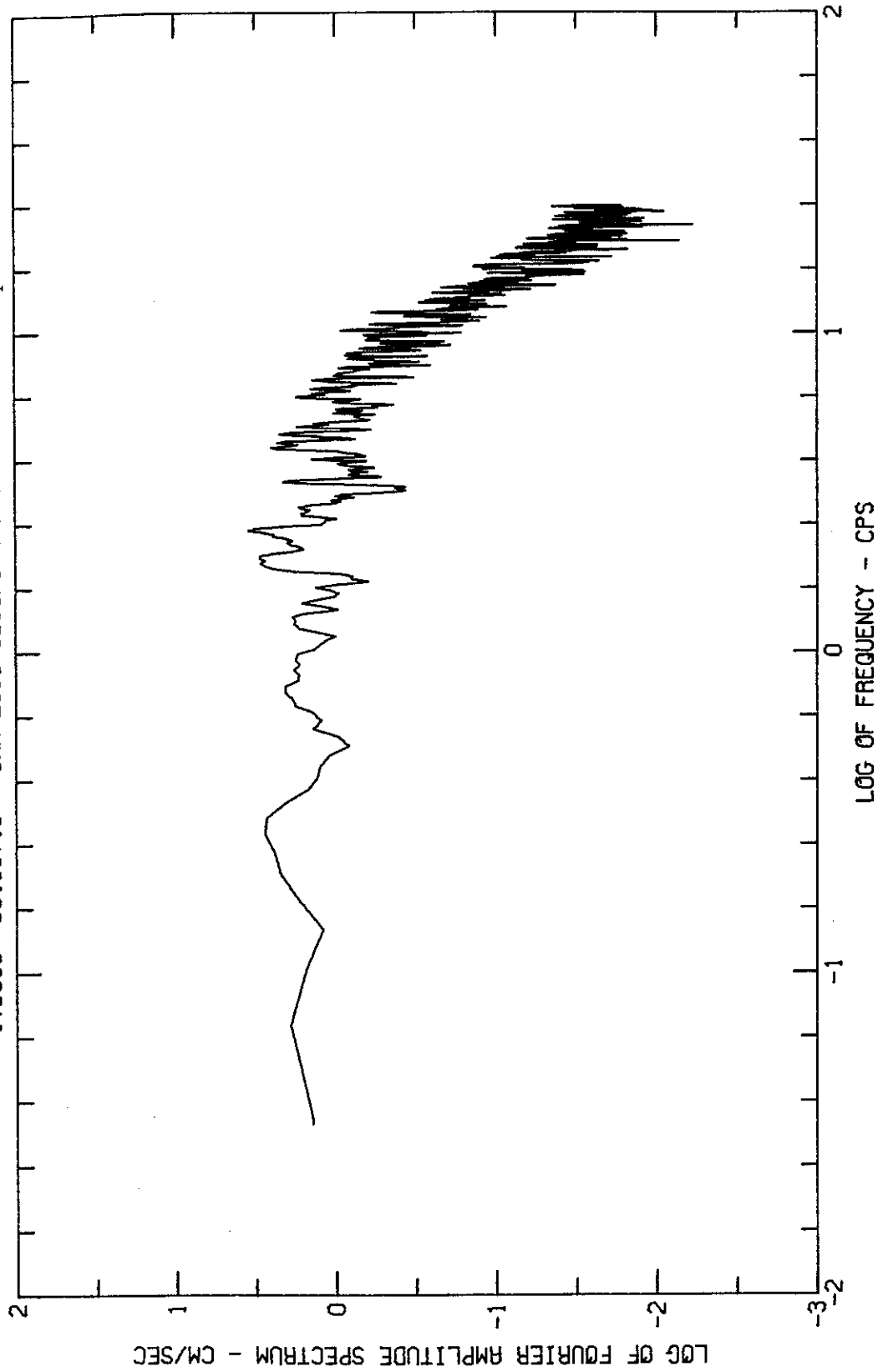
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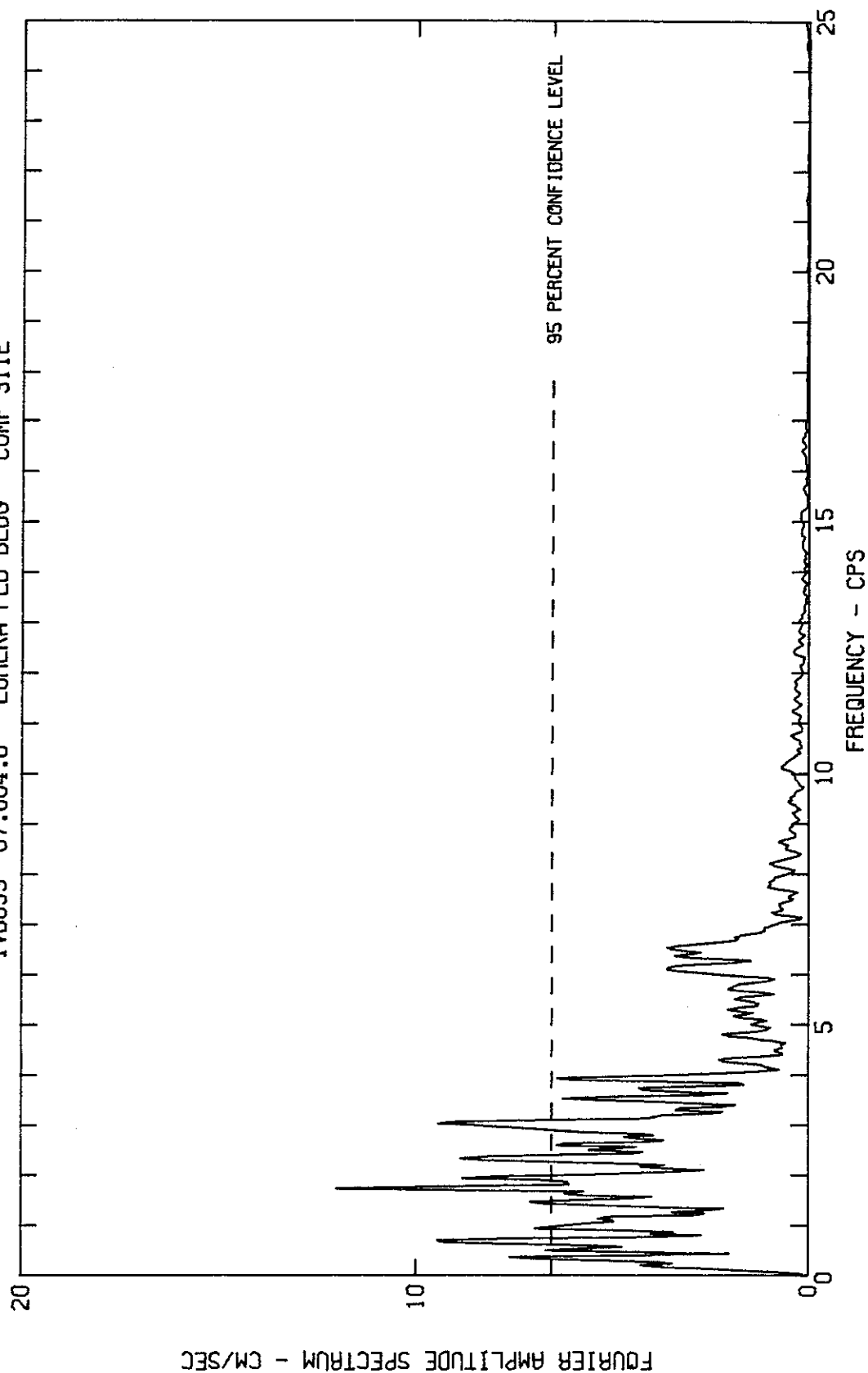
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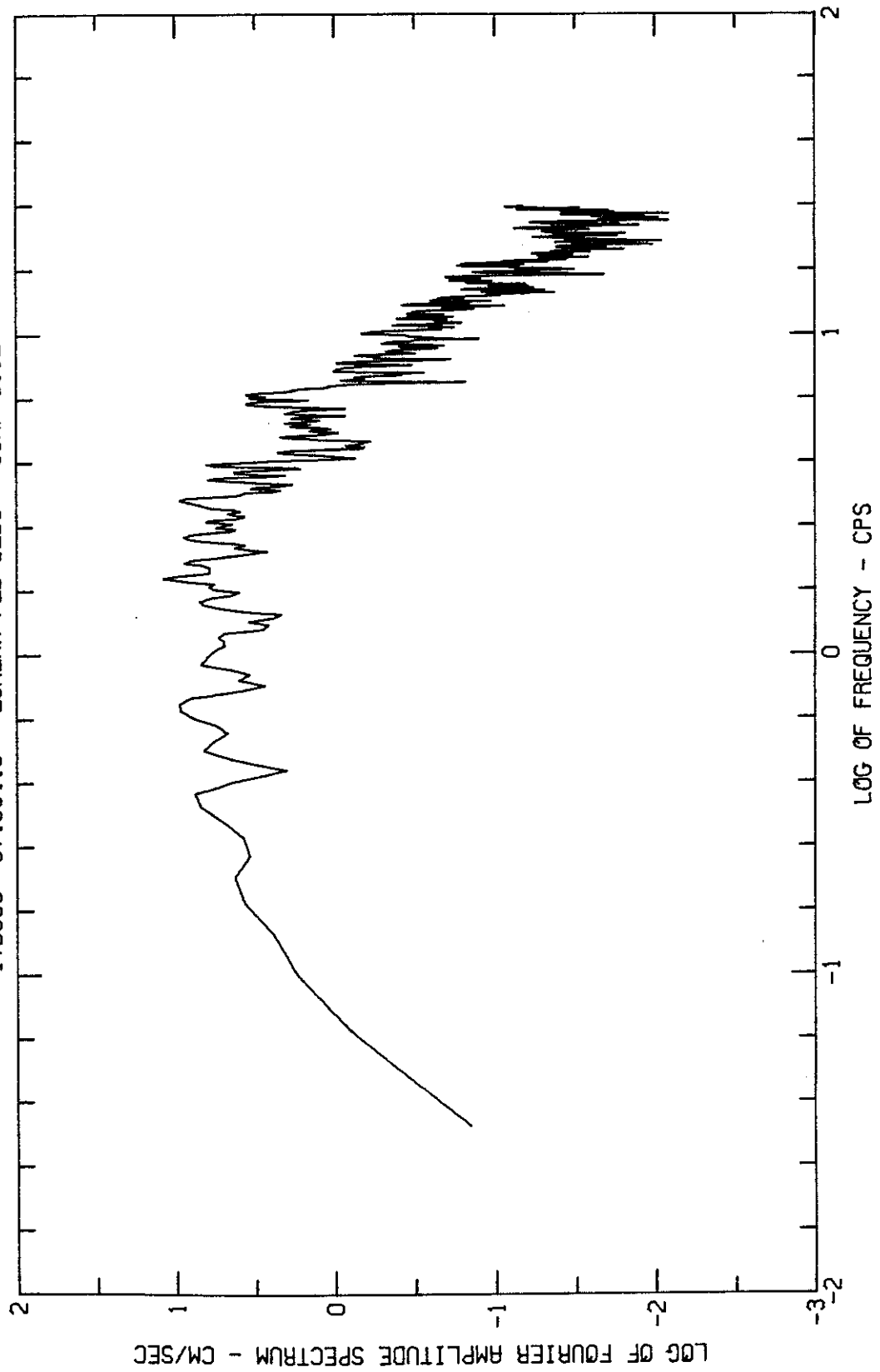
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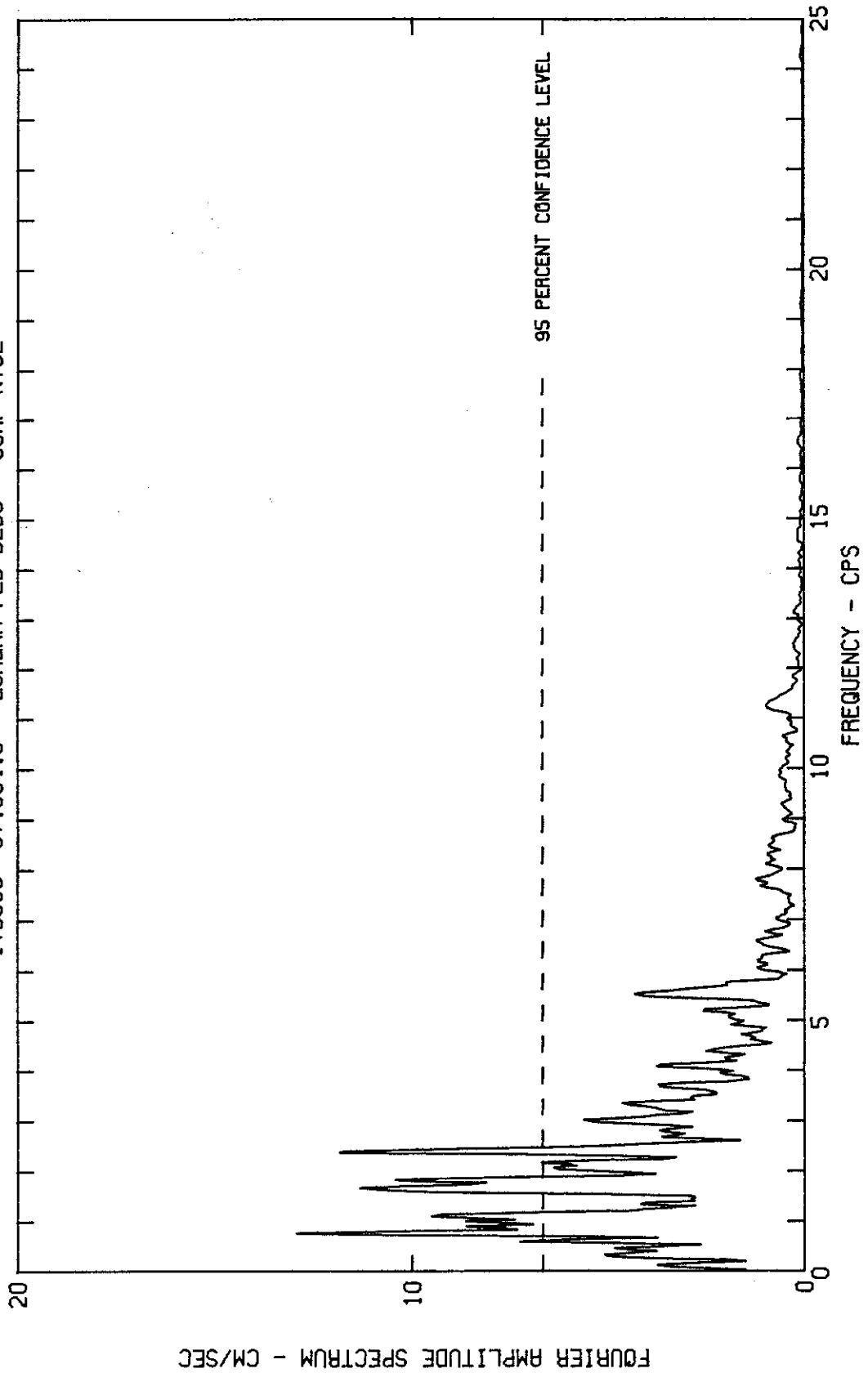
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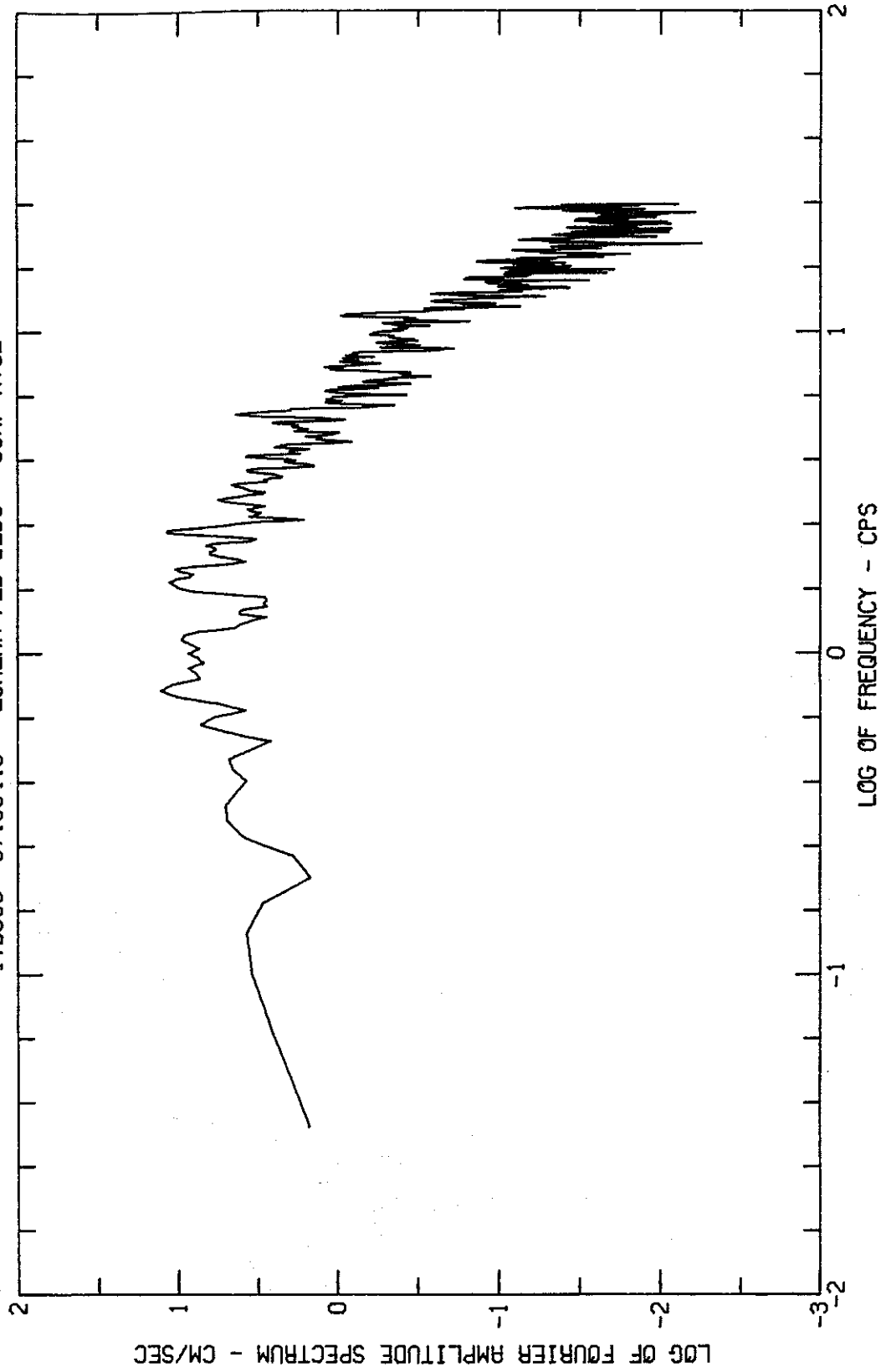
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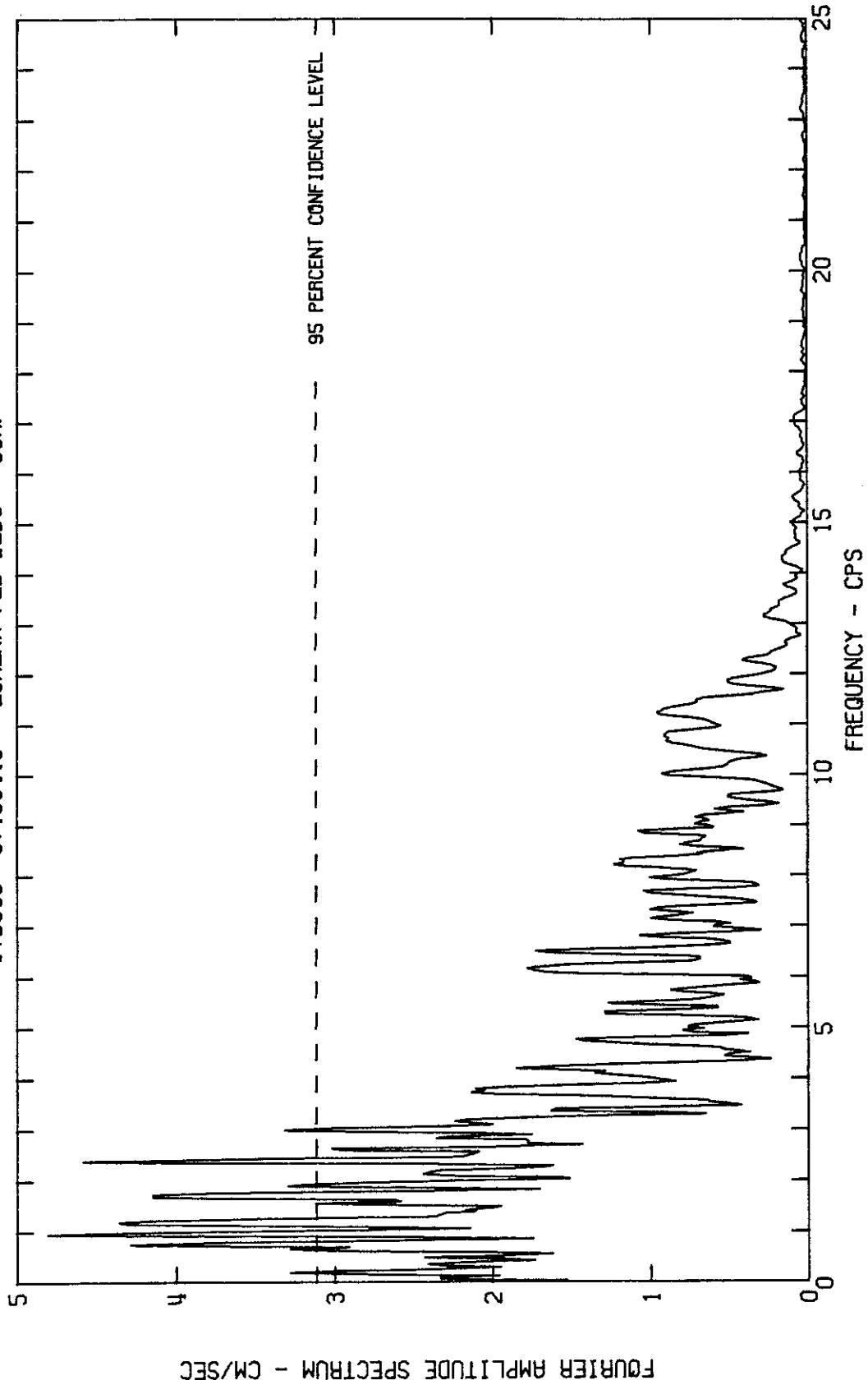
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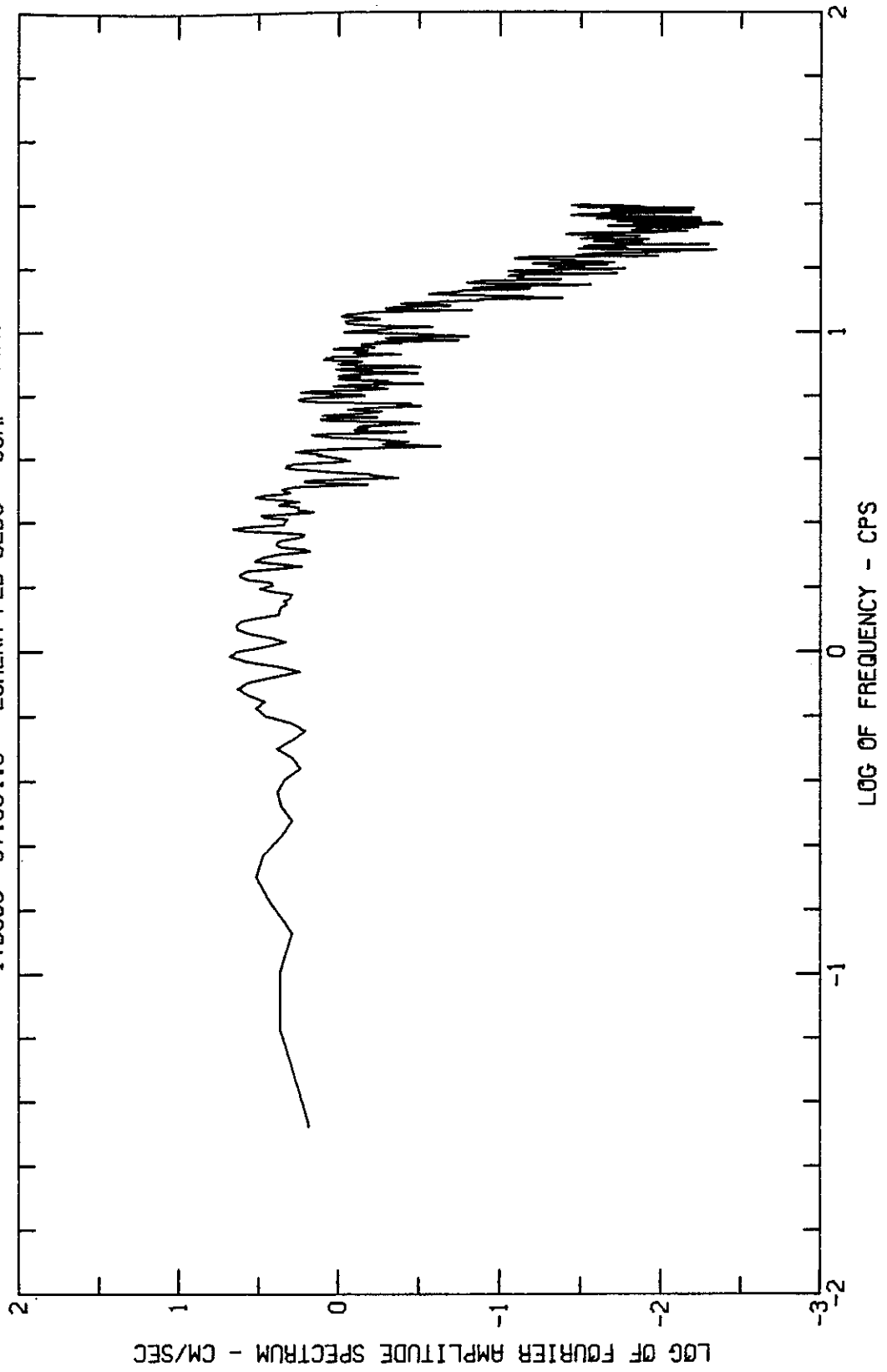
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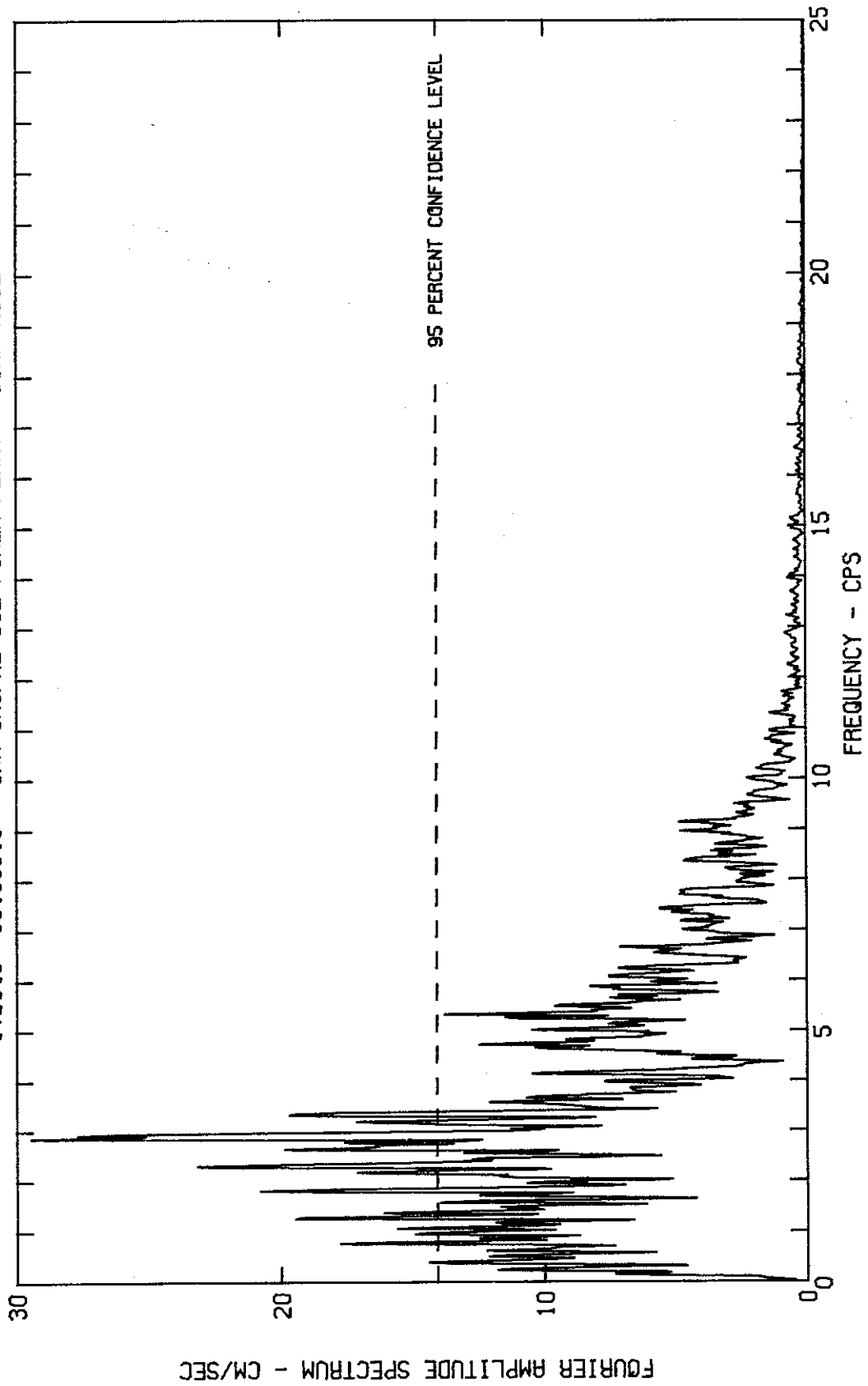
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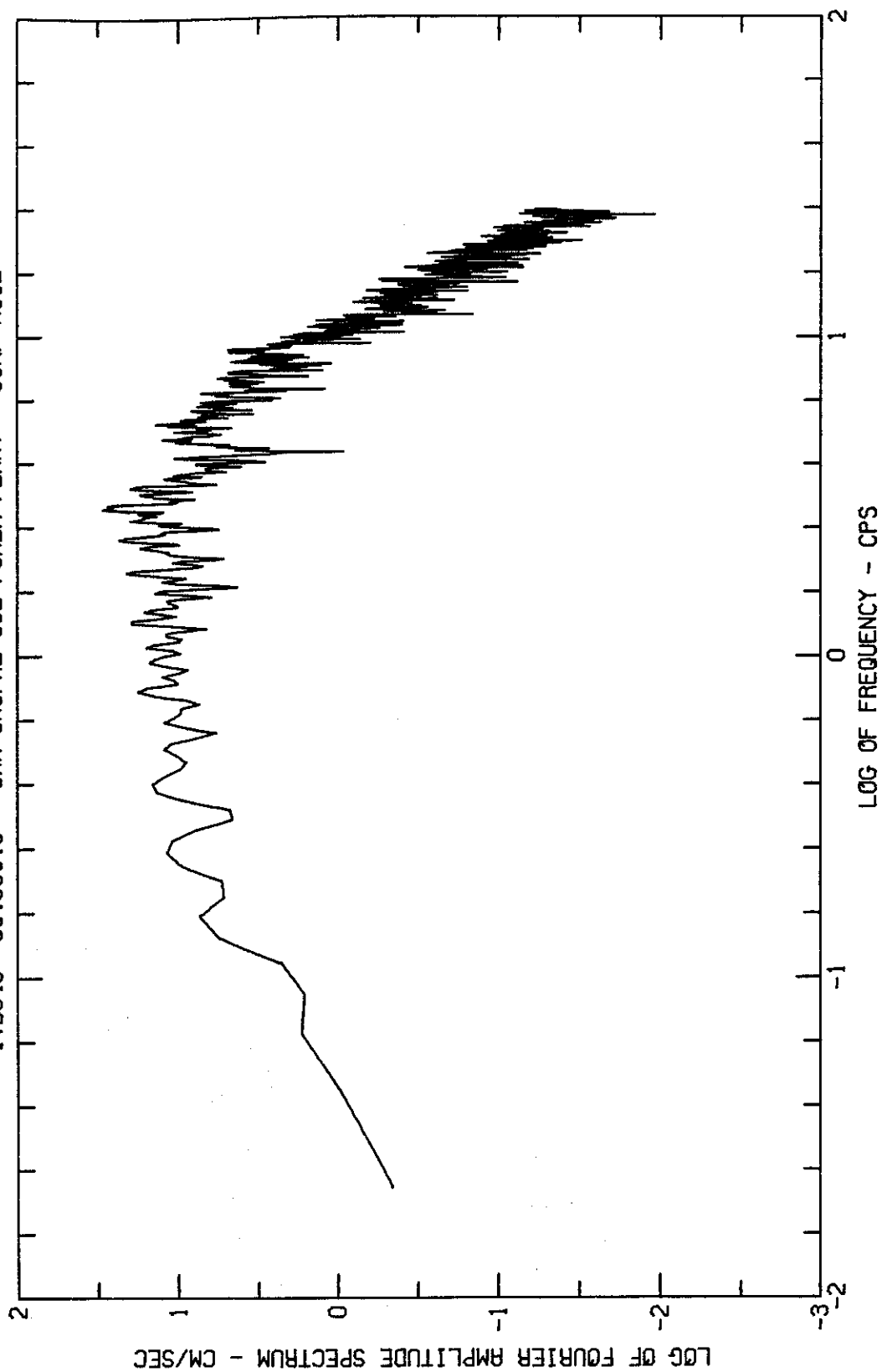
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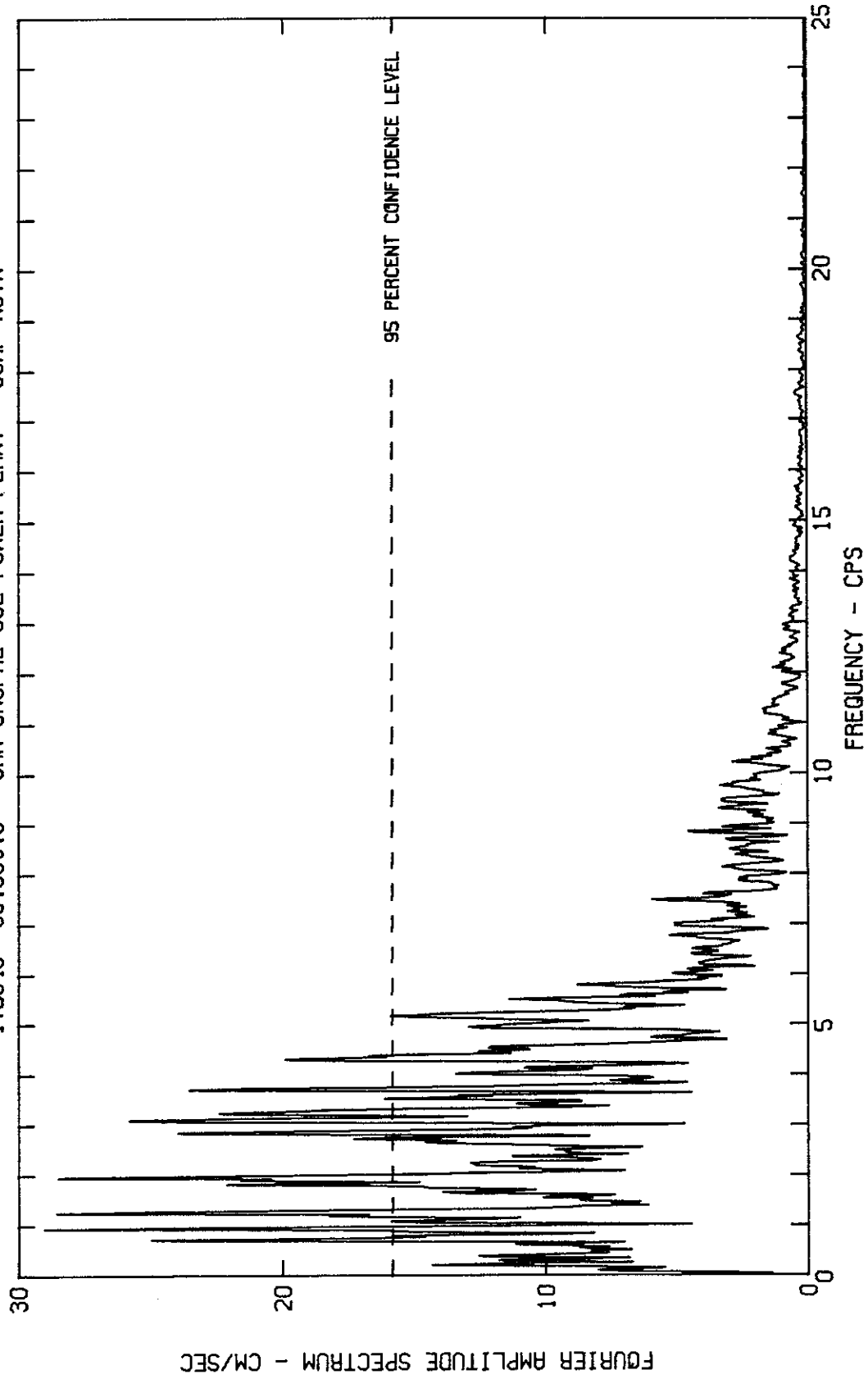
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BORREGO MOUNTAIN EARTHQUAKE APR 8, 1968 - 1830 PST
IVBO40 68.008.0 SAN ONOFRE SCE POWER PLANT COMP N33E



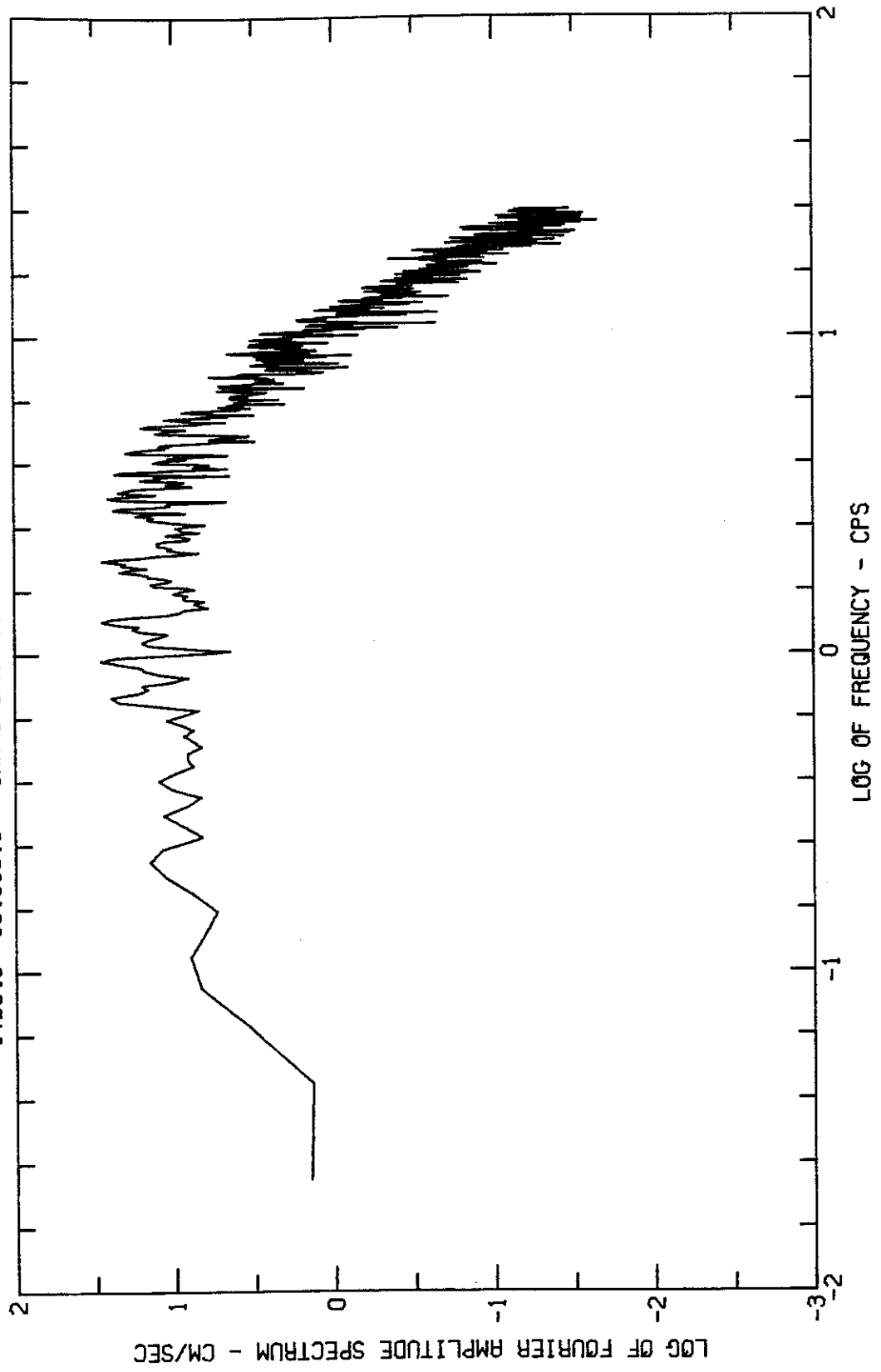
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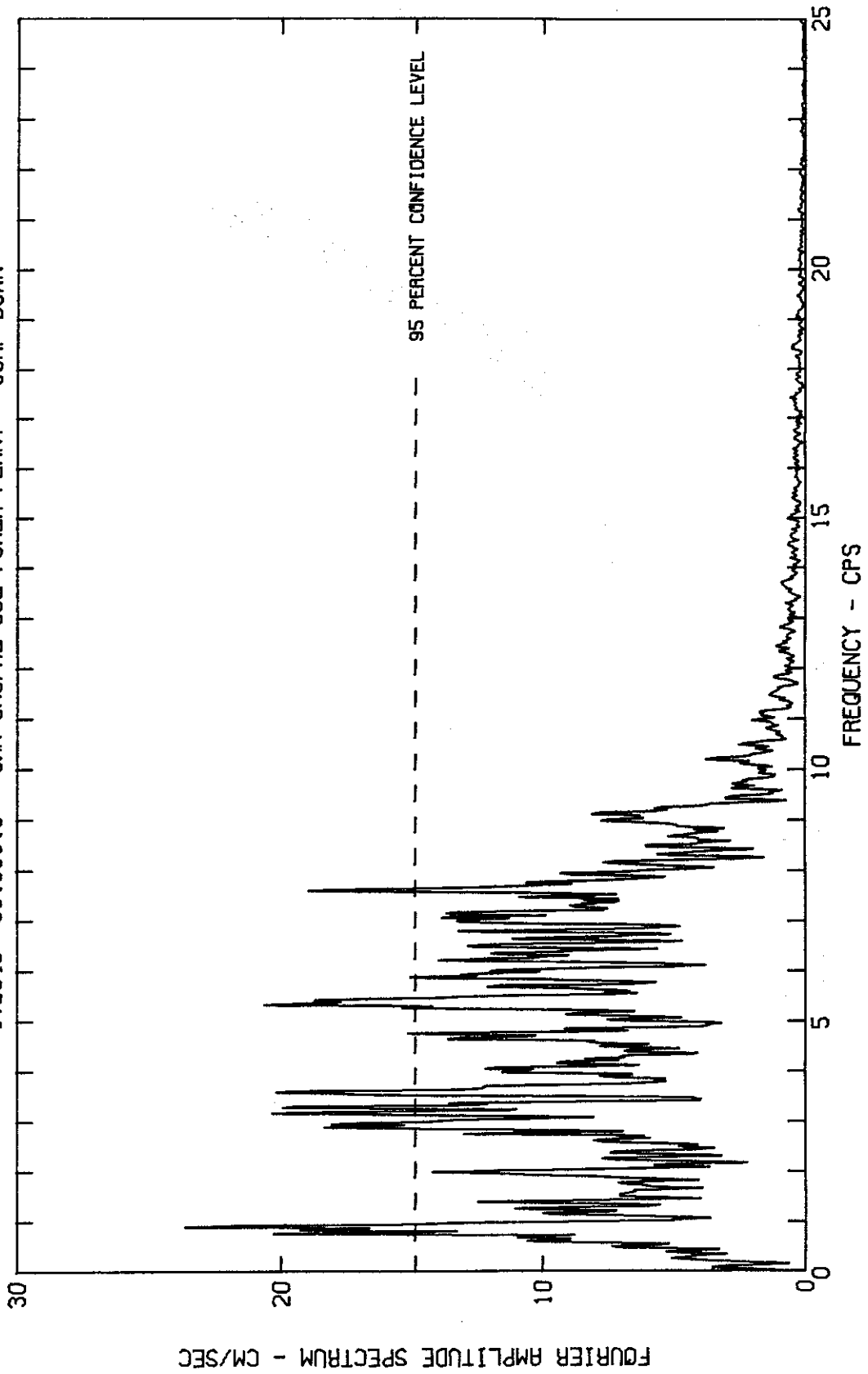
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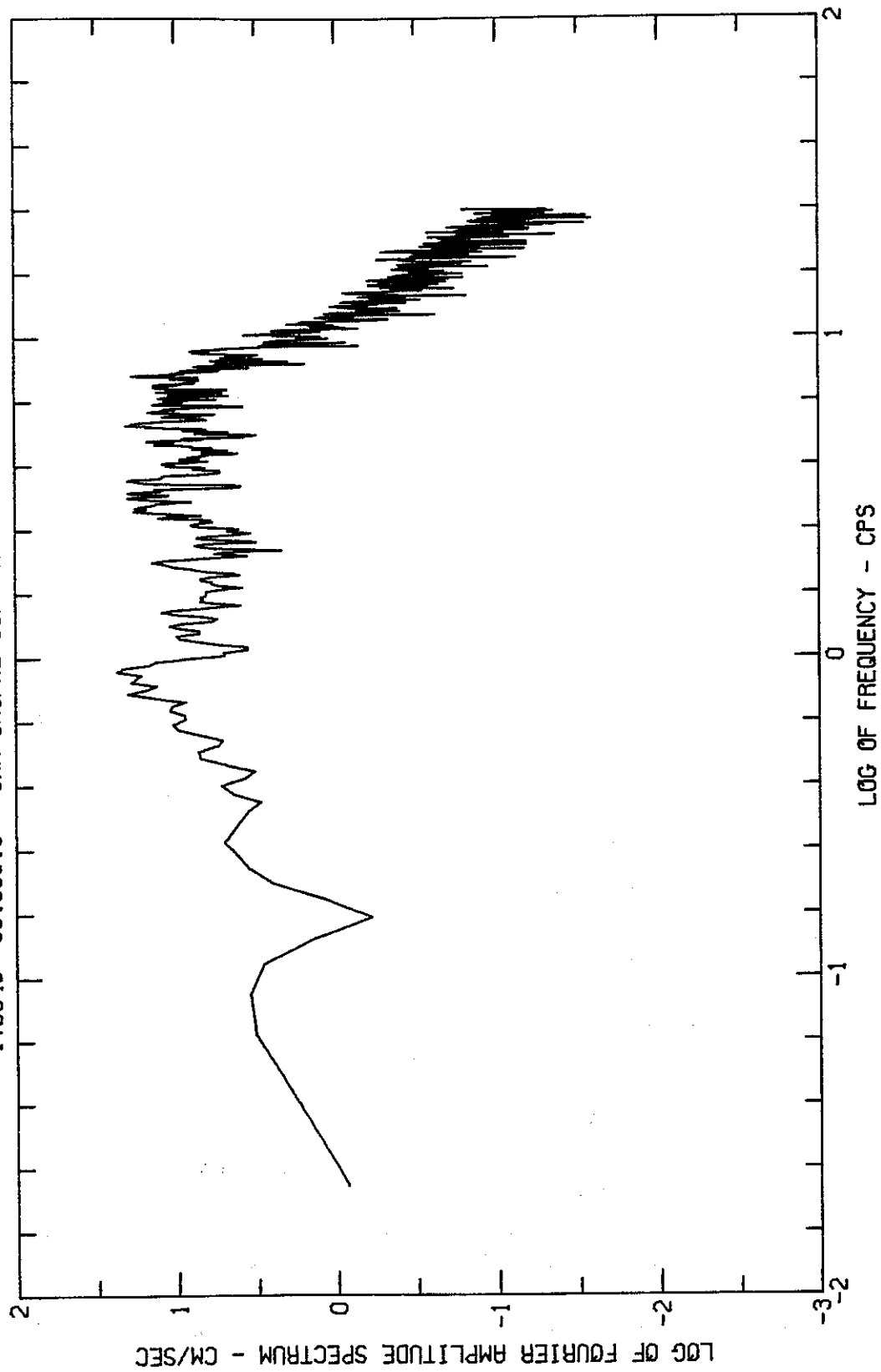
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BORRERO MOUNTAIN EARTHQUAKE APR 8, 1968 - 1830 PST
IV8040 68.008.0 SAN GINO FRE SCE POWER PLANT COMP N57W



FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
BORRERO MOUNTAIN EARTHQUAKE APR 8, 1968 - 1830 PST
IV8040 68.008.0 SAN ONOFRE SCE POWER PLANT COMP DOWN



FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
BORREGO MOUNTAIN EARTHQUAKE APR 8, 1968 - 1830 PST
IVB040 68.008.0 SAN ONOFRE SCE POWER PLANT COMP DOWN



California Institute of Technology
Earthquake Engineering Research Laboratory

The following reports of the Earthquake Engineering Research Laboratory from 1970 on can be obtained from the National Technical Information Service, Springfield, Virginia 22151:

EERL 70-20	Strong-Motion Earthquake Accelerograms - Digitized and Plotted Data (Vol.I, Part A)	PB-187 847
EERL 70-21	" " (Vol.I, Part B)	PB-196 823
EERL 71-20	" " (Vol.I, Part C)	PB-204 364
EERL 71-21	" " (Vol.I, Part D)	PB-208 529
EERL 71-22	" " (Vol.I, Part E)	PB-209 749
EERL 71-23	" " (Vol.I, Part F)	PB-210 619
EERL 72-20	" " (Vol.I, Part G)	PB-211 357
EERL 72-21	" " (Vol.I, Part H)	PB-211 781
EERL 72-22	" " (Vol.I, Part I)	PB-213 422
EERL 72-23	" " (Vol.I, Part J)	PB-213 423
EERL 72-24	" " (Vol.I, Part K)	PB-213 424
EERL 72-25	" " (Vol.I, Part L)	PB-215 639
EERL 71-50	Strong-Motion Earthquake Accelerograms - Digitized and Plotted Data: Corrected Accelerograms and Integrated Ground Velocity and Displacement Curves (Vol.II, Part A)	PB-208 283
EERL 72-80	Analyses of Strong Motion Earthquake Accelerograms - Response Spectra (Vol.III, Part A)	PB-212 602
EERL 72-100	Analyses of Strong Motion Earthquake Accelerograms - Fourier Amplitude Spectra (Vol.IV, Part A)	PB-212 603
Joint Report:	Strong-Motion Instrumental Data on the San Fernando Earthquake of February 9, 1971	PB-204 198
EERL 71-01	P. C. Jennings <u>et al</u> , Forced Vibration of a 22-Story Steel Frame Building	PB-205 161
EERL 71-02	P. C. Jennings, ed., Engineering Features of the San Fernando Earthquake	PB-202 550
EERL 71-03	Randolph A. Adu, Response and Failure of Structures under Stationary Random Excitation	PB-205 304
EERL 71-04	Jacobo Bielak, Earthquake Response of Building-Foundation Systems	PB-205 305

EERL 71-05	M. D. Trifunac, F. E. Udwadia, A. G. Brady, High Frequency Errors and Instrument Corrections of Strong-Motion Accelerograms	PB-205 369
EERL 71-06	Knut Sverre Skattum, Dynamic Analysis of Coupled Shear Walls and Sandwich Beams	PB-205 267
EERL 71-07	John Brent Hoerner, Modal Coupling and Earthquake Response of Tall Buildings	PB-207 635
EERL 72-01	P. C. Jennings and J. Bielak, Dynamics of Building-Soil Interaction	PB-209 666
EERL 72-02	F. E. Udwadia, Investigation of Earthquake and Microtremor Ground Motions	PB-212 853
DRC 72-01	Albert W. Whitney, On Insurance Settlements Incident to the 1906 San Francisco Fire	PB-213 256
EERL 72-04	J. H. Wood, Analysis of the Earthquake Response of a Nine-Story Steel Frame Building during the San Fernando Earthquake	PB-215 823